CLIC Civil Engineering & Infrastructure

John Osborne – Matthew Stuart SMB-SE-FAS

Introduction - Content

- Who is involved and what are the objectives of the CEIS Working Group?

- Updates since the CDR?
    - Civil Engineering
    - Cooling and Ventilation
    - Electrical (CLIC Power Supply).

- Further Study for each discipline within the CEIS Working Group.

Main CEIS study areas

Discipline
Civil Engineering
Survey and Alignment
Transport Installation
Safety Systems
Cooling and Ventilation
Electrical

General Objective: *Develop the existing layouts for the project from a civil engineering and technical infrastructure point of view, and work with the various actors towards a realistic design and project planning as needed for the 'CLIC Implementation Plan', due late 2018.*

What are the Objectives?

Specific responsibilities:

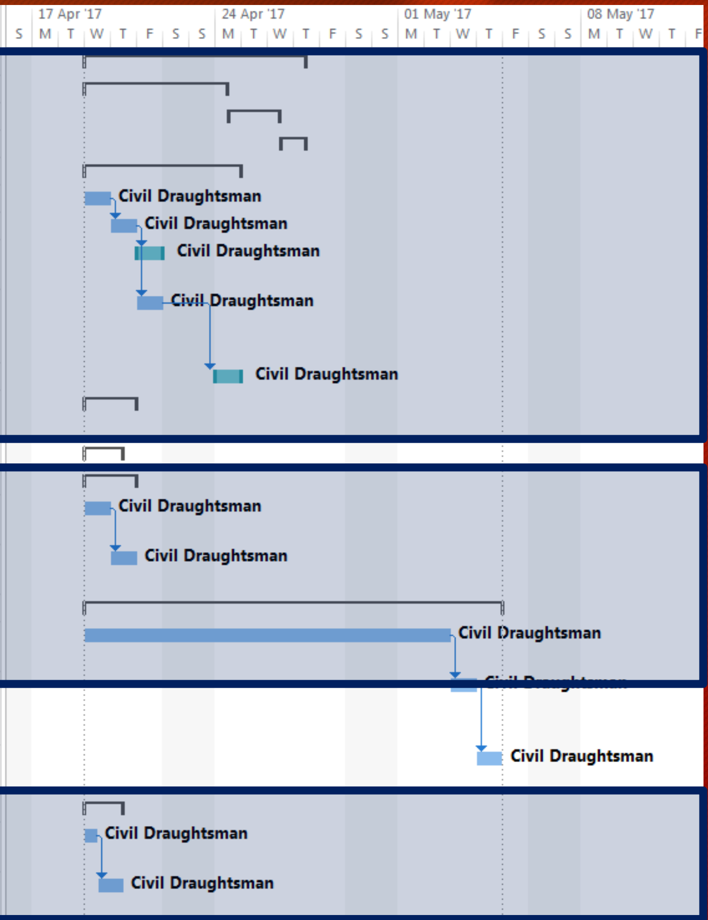
- Develop new and/or update civil engineering layouts for 380GeV, 1.5TeV and 3TeV machine.
- Develop new civil engineering layout for 380GeV machine using Klystron technology.
- Update the tunnel design and layout to accommodate the machine (e.g. ventilation, electrical equipment, survey, controls, safety and handling equipment).
- Develop a layout for the interaction region.
- Study environmental aspects of the project and siting preparation. Work together with ILC on areas of synergy.
- Produce schedule and cost estimates.
- Consider and update transport, installation and CERN logistics issues for the project.
- Technical infrastructure and installation scheduling.

What has been done – Civil Engineering Drawings

1. Civil Drawing Update

- All Layouts have been updated for the 380 GeV, 1.5 TeV & 3TeV Drive Beam design.
- New layouts and cross-sections produced for the 380 GeV Klystron design.
- Surface building plans updated.
- Preliminary 3D schematic of CLIC has been produced.
- Interaction region has been updated to show the new single detector layout.

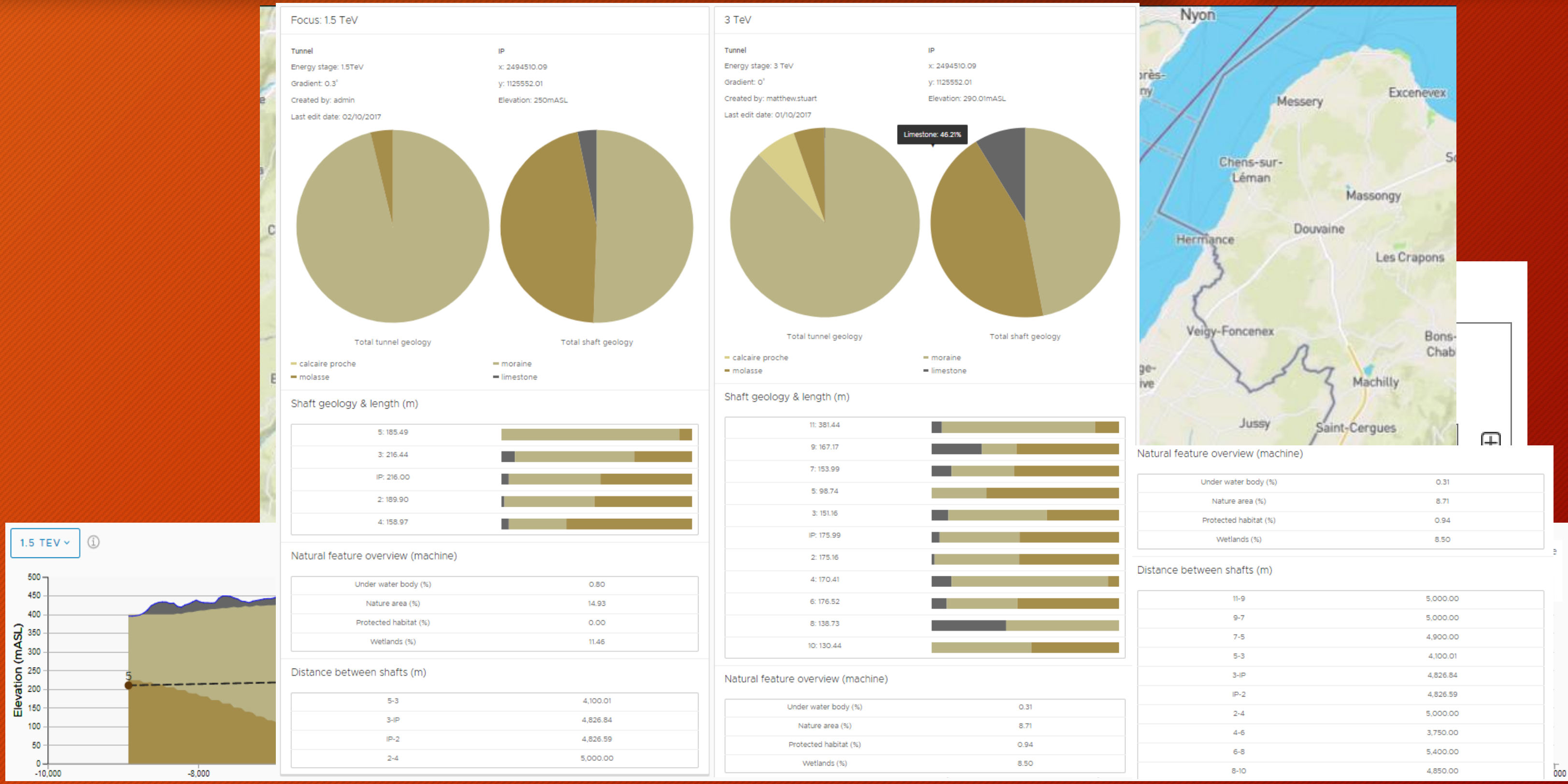
Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	Cost
	Proposed Tunnel Layout	**6.5 days**	**Wed 19/04/17**	**Thu 27/04/17**			
	11km Tunnel Layout	**3.5 days**	**Wed 19/04/17**	**Mon 24/04/17**			
	29km Tunnel Layout	**2 days**	**Mon 24/04/17**	**Wed 26/04/17**			
	55km Tunnel Layout	**1 day**	**Wed 26/04/17**	**Thu 27/04/17**			
	Klystron Layouts	**4 days?**	**Wed 19/04/17**	**Mon 24/04/17**			
	11km Single Tunnel	1 day	Wed 19/04/17	Wed 19/04/17		Civil Draughtsman	
	11km Double Tunnel	1 day	Thu 20/04/17	Thu 20/04/17	15	Civil Draughtsman	
	Klsytron Injection Complex Layout	1 day	Fri 21/04/17	Fri 21/04/17	16	Civil Draughtsman	
	Cross section of Klystron single and double tunnel	1 day?	Fri 21/04/17	Fri 21/04/17	16	Civil Draughtsman	
	Klsytron Shaft Layout	1 day	Mon 24/04/17	Mon 24/04/17	18	Civil Draughtsman	
	Detail 01 (plan and Cross-Sections)	**2 days**	**Wed 19/04/17**	**Thu 20/04/17**			
	BDS Detail	**1.5 days**	**Wed 19/04/17**	**Thu 20/04/17**			
	Surface Buildings	**2 days**	**Wed 19/04/17**	**Thu 20/04/17**			
	Central Injection Complex Layout	1 day	Wed 19/04/17	Wed 19/04/17		Civil Draughtsman	
	Drive/Main beam buildings	1 day	Thu 20/04/17	Thu 20/04/17	27	Civil Draughtsman	
	3D Drawings	**12 days**	**Wed 19/04/17**	**Thu 04/05/17**			
	3D perspective of all stages	10 days	Wed 19/04/17	Tue 02/05/17		Civil Draughtsman	
	3D Drawing IR Region (Including all caverns/shafts)	1 day	Wed 03/05/17	Wed 03/05/17	30	Civil Draughtsman	
	3D perspective of detail 01	1 day	Thu 04/05/17	Thu 04/05/17	31	Civil Draughtsman	
	IR plan and cross sections	**1.5 days**	**Wed 19/04/17**	**Thu 20/04/17**			
	Plan of IR (caverns shafts etc...)	0.5 days	Wed 19/04/17	Wed 19/04/17		Civil Draughtsman	
	Cross sections of IR (Caverns, shafts etc...)	1 day	Wed 19/04/17	Thu 20/04/17	34	Civil Draughtsman	



What has been done – Civil Engineering Tunnel Optimisation Tool

CLIC proposals:

- Main Map Layer
  - Includes different surface and subsurface constraints.
  - Detailed information of Individual Shafts
  - Geological cross-section
- User Inputs:
  - IP co-ordinates
  - IP Depth
  - Angle of rotation – vertical and horizontal plane.
  - Energy stage
- Outputs
  - Shaft lengths
  - Tunnel and Shaft geology
  - Depth of tunnel below any watercourses
  - Amount of clashes with geothermal boreholes.
  - % of tunnel passing through depressions with complex geology.
- Comparison Overview
  - Page showing an overview of the options
  - Can compare up to 3 options side by side.

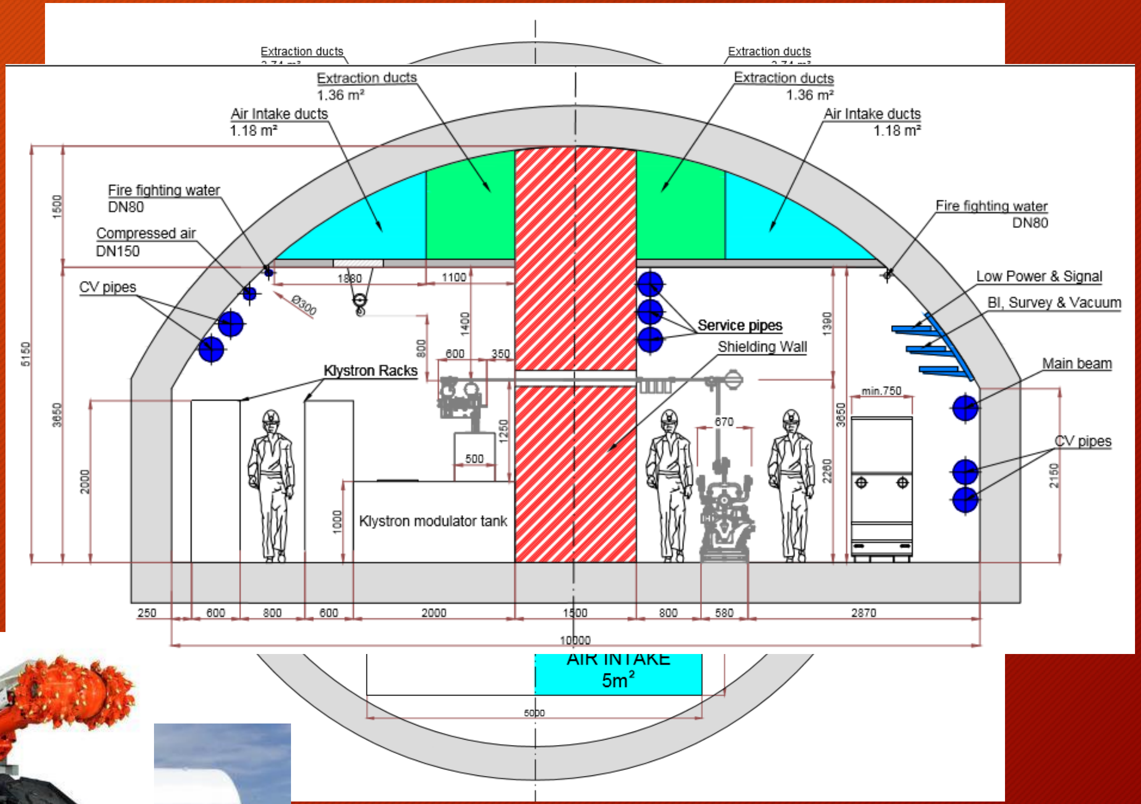


<u>CLIC Tunnel Optimisation Tool</u> *– The tunnel optimisation tool has been produced to provide a means of analysing the possible locations for CLIC, it allows the user to look in detail at a number of factors that need to be considered when choosing a location for the different energy stages.*

What has been done – Civil Engineering

Two options for the Klystron Tunnel have been looked at:

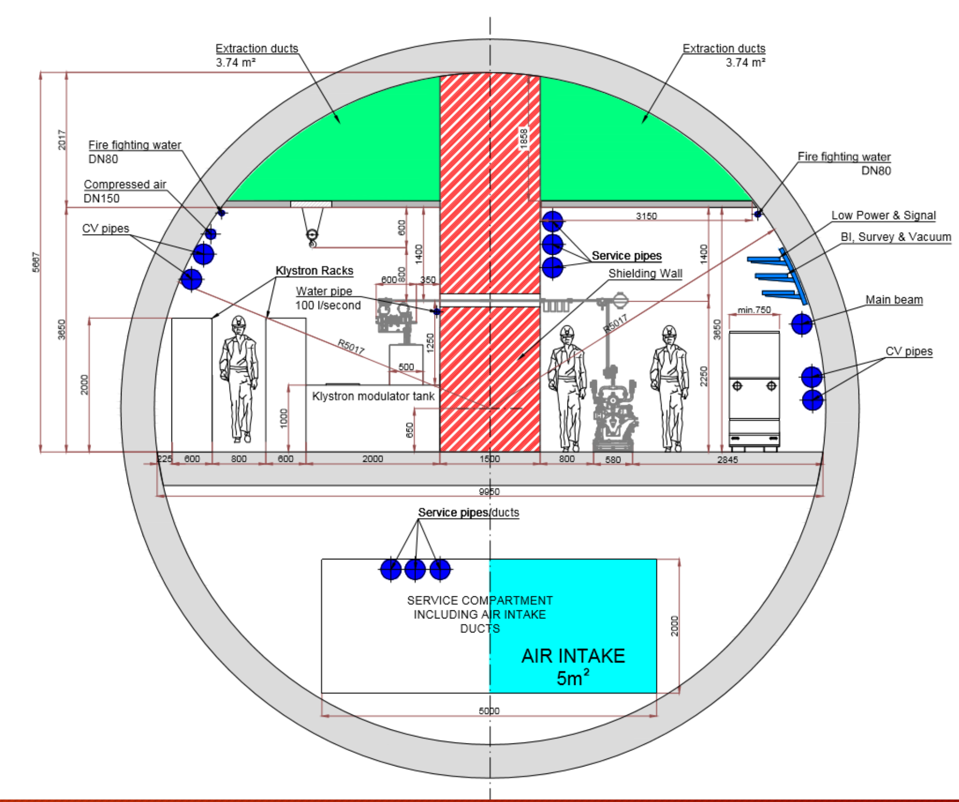
1. 10m wide Roadheader mined tunnel.
   - Shape can be determined by tunnel requirements.
   - No wasted space below the tunnel floor.
   - Can mine through “bad rock”
2. 10m internal Diameter TBM Bored tunnel.
   - Considerably quicker rate of excavation through “good rock”.
   - Cheaper per m of tunnel construction for this length of tunnel.
   - Under floor space can be utilised for services to avoid wasted space.



What has been done – Civil Engineering

10m Internal Diameter TBM tunnelling method is proposed for the Klystron 380 GeV design:

- The cost for an 11km tunnel for the TBM is 10% cheaper than a mined tunnel.
- The underfloor space can be utilised and therefore reduce the amount of wasted space.
- The excavation rate per m of tunnel is considerably quicker for a TBM and therefore construction time is reduced.
- The geology for the 380 GeV is expected to be majority molasse.



What has been done - CV

The cooling and ventilation is a critical aspect of the tunnel integration design as it has a large effect on the required dimensions of the tunnel cross-section.

Due to changes in the heat loading dispersed to air and water new solutions have had to be looked into.

Centralising cooling towers results in huge pipes and booster pump requirements.

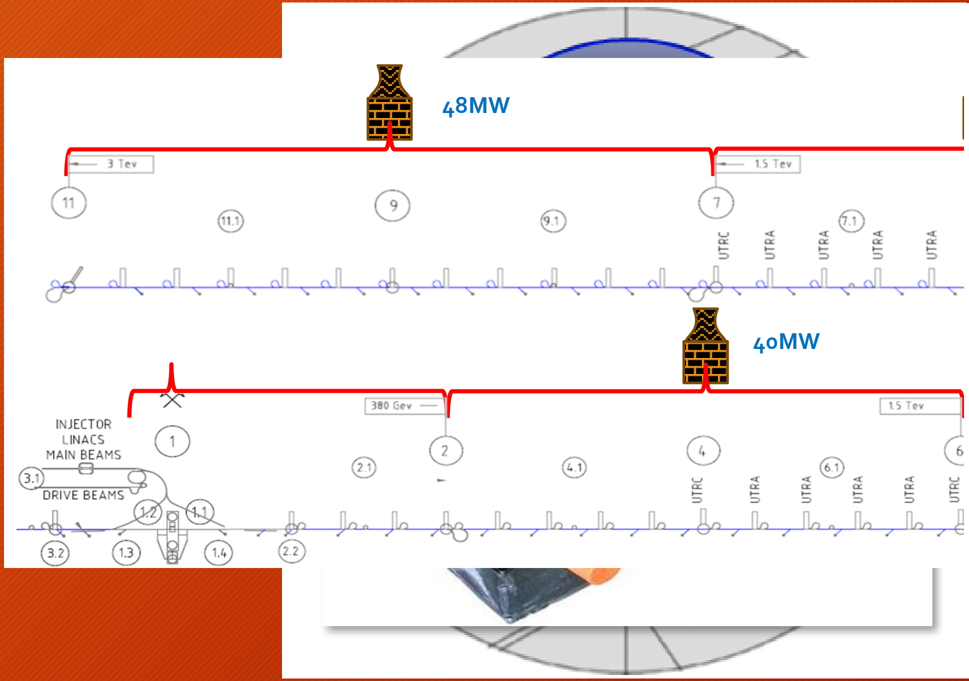
Cooling:

- New cooling towers proposed at points 4, 5, 8 and 9.

CDR tunnel ventilation not adapted for the huge air loads in the main tunnel.

Ventilation:

- Insulate/Encapsulate CLIC Modules - Install heat exchangers or fans inside the "box".
- Increase allowable temperature in the tunnel.
- Install AHU machines to tackle heat load locally



Power dissipation to air 3 TeV (CDR)		Power dissipation to air 3 TeV (New)	
Components	Power [kW]	Components	Power [kW]
RF str.	0.00	RF str.	8,751.38
Girder pre-alignment	122.77	Girder pre-alignment	40.93
MB quadrupole pre-alignment	0.00	MB quadrupole pre-alignment	0.00
WFM	125.31	WFM	125.31
Vacuum system	408.00	Vacuum system	1,088.85
Beam instrumentation	228.16	Beam instrumentation	295.57
DB Q cables	408.00	DB Q cables	408.00
MB Q cables	132.00	MB Q cables	132.00
Stabilisation	184.22	Stabilisation	185.04
Others	500.00	Others	0.00
DB quadrupoles [W]	0.00	DB quadrupoles [W]	177.33
MB quadrupole [W]	0.00	MB quadrupole [W]	265.31
Total per linac [W]:	2,108,462.40	Total per linac [W]:	11,469,709.00
Total per linac [W/m]:	100.40	Total per linac [W/m]:	546.18

What has been done – Electrical (CLIC Powering)

CLIC Powering

Grid Design Solution: Since 2012 TE/EPC has focussed on RF powering and has made steps toward the powering grid design, this includes the proposed solution as seen here:

- 6 sectors for RF power distribution (3 TeV)
- Each sector needs a substation/location.
- One substation needs an indoor space of (**very** roughly): ~ 1500 m2 x 10m height

EN/EL - Availability of Power:

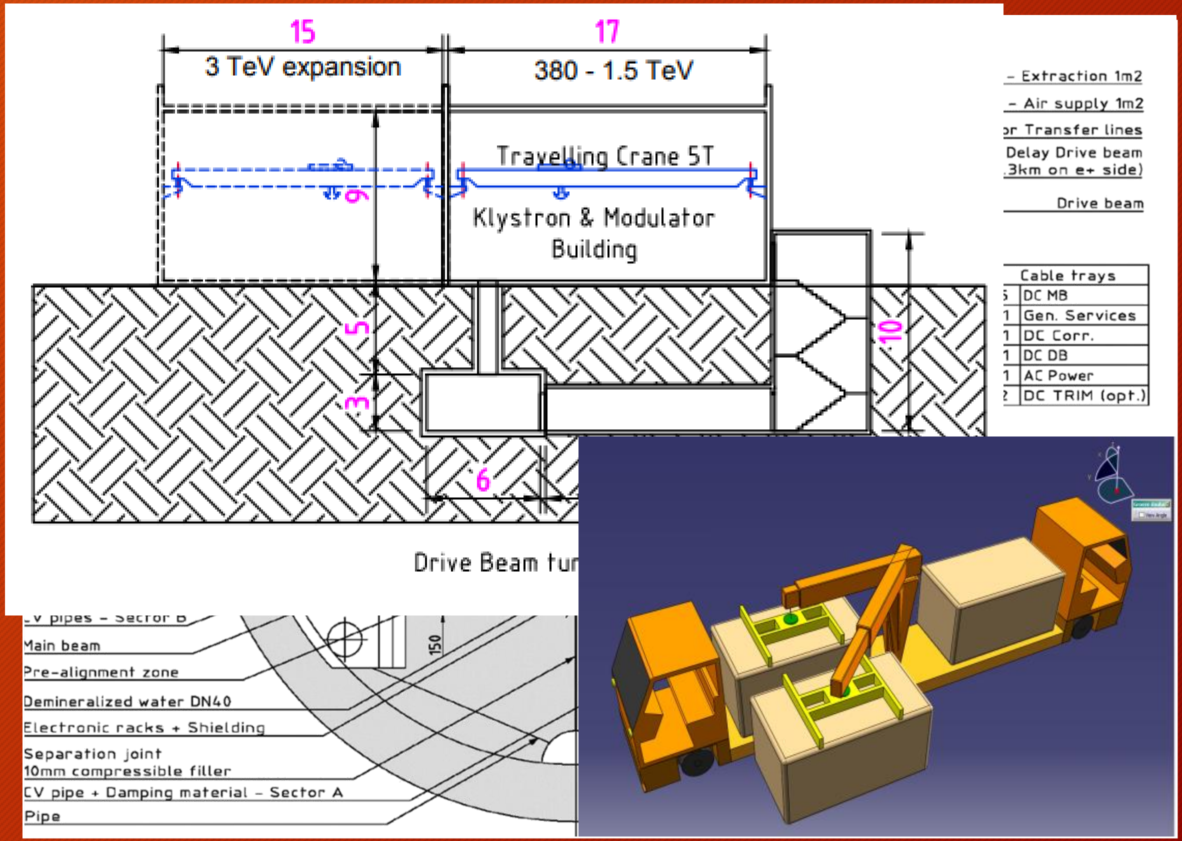
- Power available at European grid level 200MW available at each 400kV source.
- Approximately 70,000m^2 of outdoor surface space to be allocated for connection to the 400kV European grid.

Further Study

Transport:
- An updated items list for transport is required for both the Klystron and the Drive beam design.
- Decision to be made on travelling crane or vehicle transport within the drive beam building.
- Transportation logistics need to be studied to allow a construction and installation schedule to be produced.

Cooling and Ventilation:
- Update of heat loads from ALL users is required to allow a solution to be implemented properly.
- Smoke extraction and radiation protection systems need to be integrated into the requirements (to be done with safety).
- Finalise the solutions for both Cooling and Ventilation.

Safety:
- Identification of hazards and mitigations that fall under standard procedure.
- Hazard register to be produced and populated by all disciplines.
- HSE meetings to be arranged for each discipline to identify associated hazards.



Further Study

Survey and Alignement:

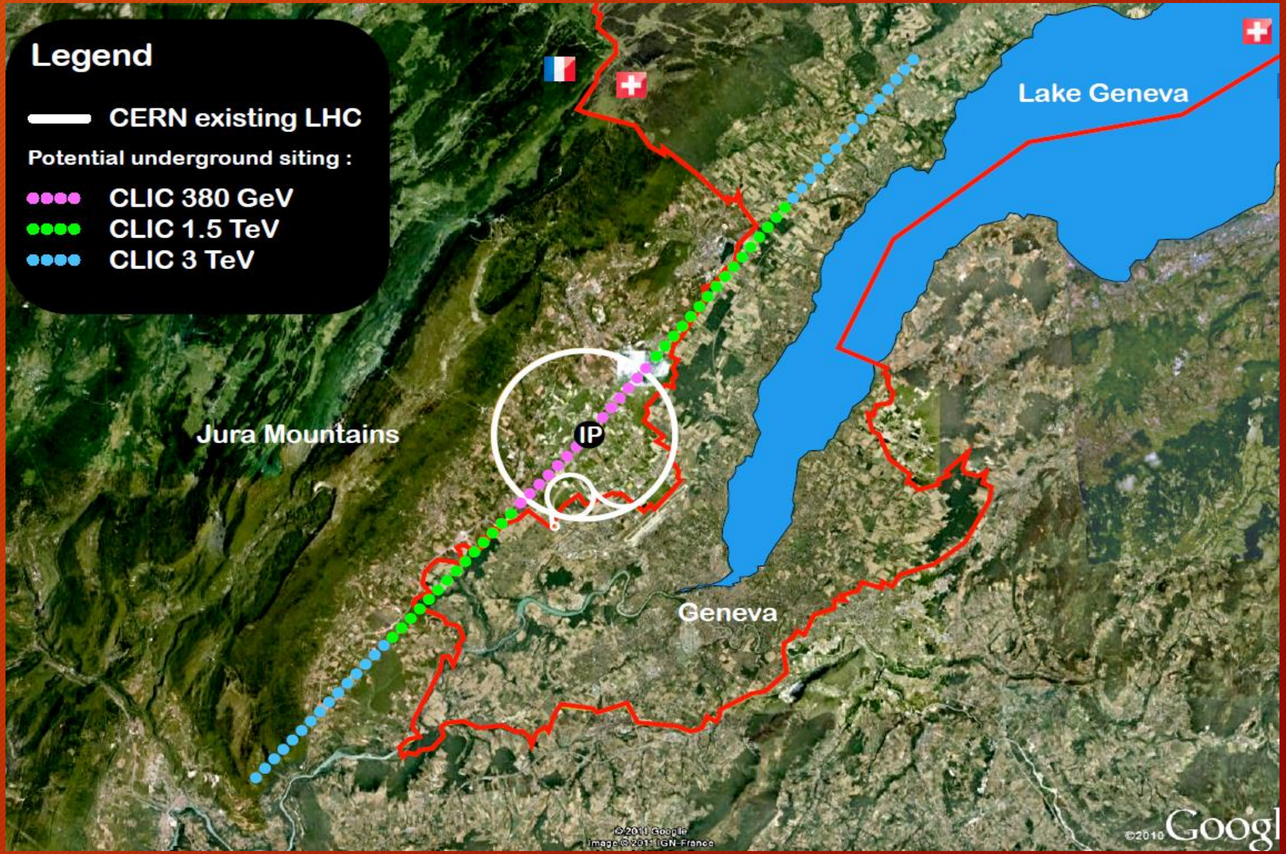
- Lattice file translations required for the 1.5 TeV and 3 TeV Drive Beam design.

Civil Engineering

- Use CLIC TOT to optimise the position of the tunnel for the different energy stages.
- Continue to update and integrate all disciplines into the surface and tunnel layouts and designs.

Electrical:

- Electrical equipment requirements for both the Drive beam and the Klystron design are to be integrated into the tunnel design, including electrical alcove requirements.
- Power supply for CLIC from European grid level requires consultation and approval from authorities.



Summary

CEIS Working Group:

- Meetings for the CEIS Working Group are taking place every 5 weeks to ensure full integration of the work done by each discipline.
- Full Activity tracker updated at each meeting outlining the tasks for each discipline.

Updates since CDR:

- Civil Engineering Layouts have been updated and new Klystron layouts have been produced.
- CLIC TOT has been produced and is available to start optimising the position of the CLIC tunnels and surface locations.
- HVAC has been studied in more detail, the heat loads have been updated and new cooling and ventilation systems/solutions have been proposed.
- CLIC Power supply requirements have been proposed with an update on the substation requirements and the connection to the European grid.

Further Study:

- CLIC tunnel optimisation to be studied in detail.
- Solutions proposed for the cooling and ventilation require input from all disciplines responsible for heat loading so a more detailed design can be produced.
- Agreement for local authorities required for connection to the European grid.
- Safety to produce and populate a hazard register for the CLIC Project.
- Transport design and schedule to be completed – requires an updated list of items that are to be transported throughout the shafts and tunnel.
- Survey and Alignment to provide lattice files for the 1.5 TeV and 3 TeV energy stages.

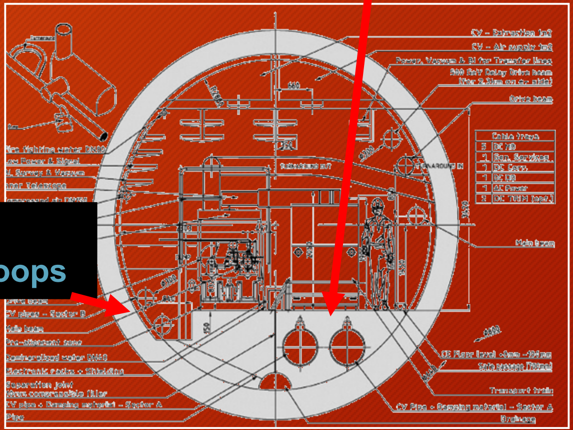
Thank You For Your Attention

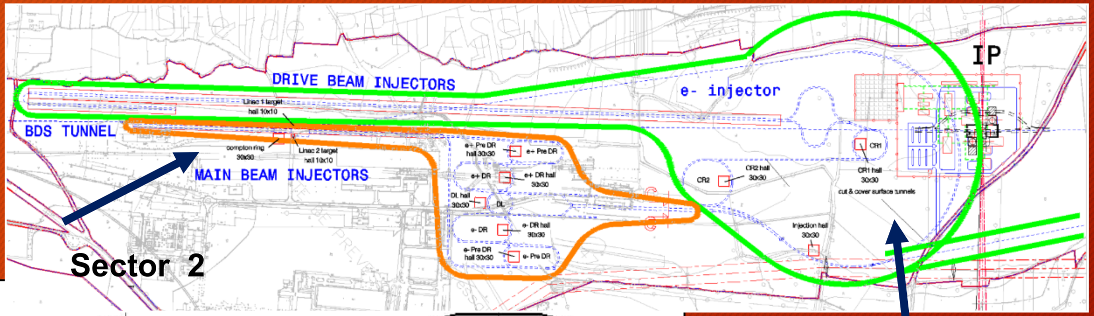
Thank you to all contributors from the CLIC CEIS Working Group

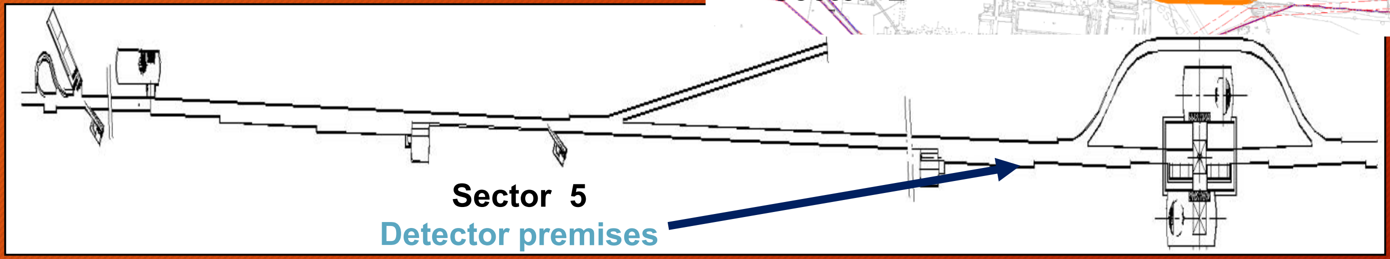
Cooling CDR Baseline

Facilities divided into 5 cooling sectors according to:

- Functional and operational requirements
- Thermal loads
- Dimensions & geographical distribution
  - Facilities (Drive beam injector building)
  - HVAC and cooling plants (keep reasonable size)
  - Environmental impact: no cooling towers on surface points -> centralised in Prévessin





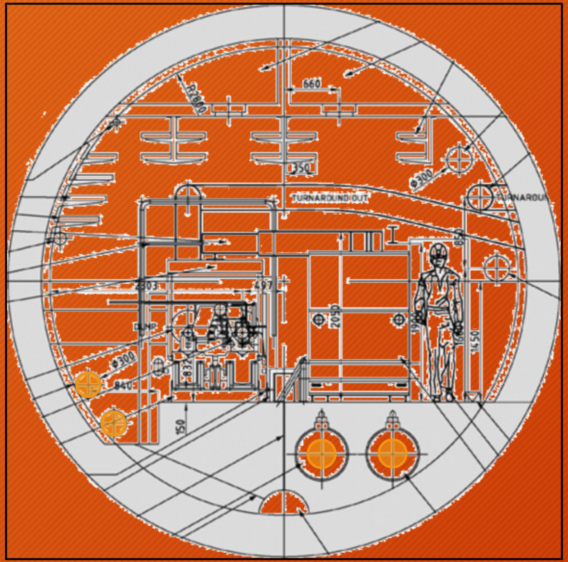


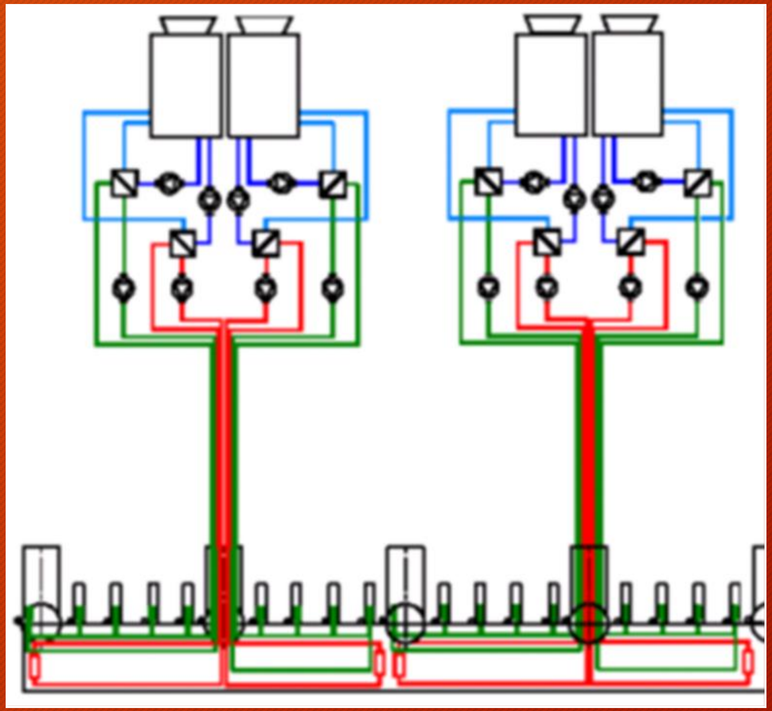
Cooling: proposed modification

Cooling towers in surface points: Pt 4, 5, 8, 9

Advantages:

- Smaller pipe diameters in tunnel
- Lower electrical power requested (25%)
- No need for booster pumps
- Bypass, connection to drain: simpler if still needed
- Easier operation (balancing of circuit, …)





Disadvantages:

- Stronger environmental impact (outside CERN)
- Bigger surface needed for installation
- Impact on shaft dimensions?

However: manifold issue still present