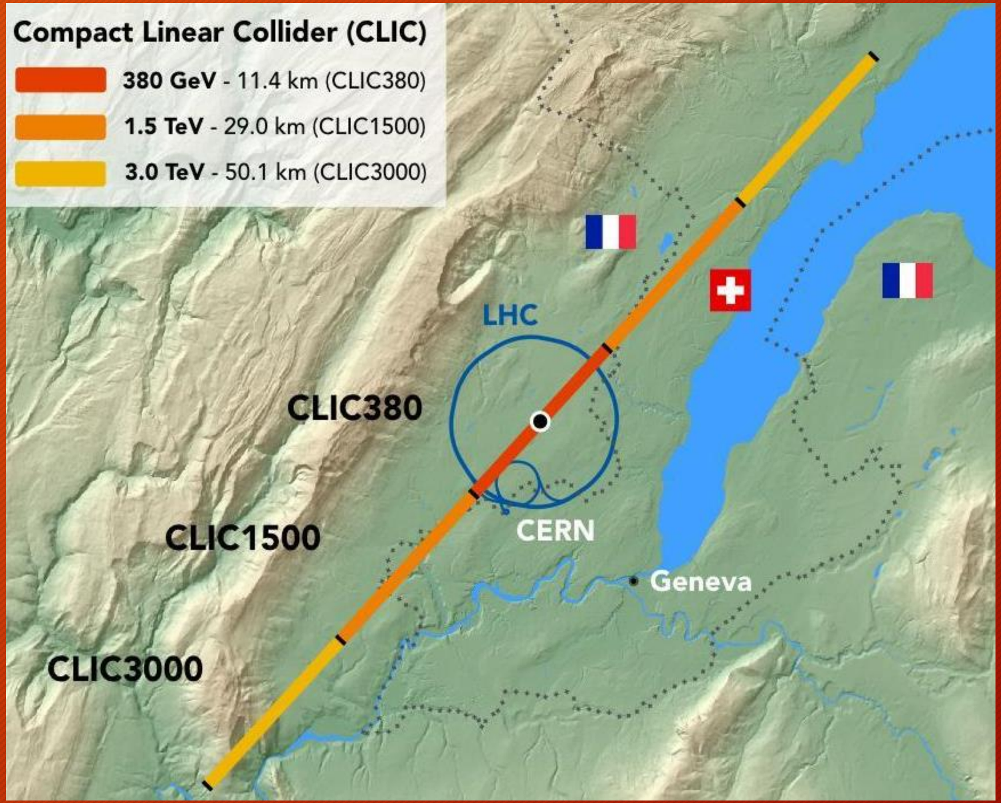
Civil Engineering, Infrastructure & Siting (CEIS) Working Group Introduction

John Osborne – Matthew Stuart SMB-SE-FAS

Introduction

- 2018 CEIS status update
- Initial Cost Estimates for 380 GeV
  - Civil Engineering
  - Transport & Handling
  - Electrical Infrastructure



Representatives of the Civil Engineering, Infrastructure & Siting (CEIS) Working Group Disciplines:

Discipline	Representative
Chair & Civil Engineering	**J.Osborne** & Matthew Stuart
CLIC Link Persons	S.Stapnes/D.Schulte/C.Rossi/R.Corsini /W.Wuensch/A.Latina/D.Aguglia
Cooling and Ventilation (CV)	M.Nonis/P.Cabral
Electricity (EL)	Davide Bozzini
Survey (SU)	H.Mainaud Durand
Transport & Handling (HE)	I.Ruehl/**Michal Czech**
Interaction Region	K.Elsener
Logistics/Lab readiness	M.Tiirakari
CE Layouts & Cross-sections	SMB/CE Design Office
Health Safety & Environment (HSE)	S.Baird/S.Marsh
Schedule	K.Foraz/Marzia Bernardini
ILC Link Persons	J.Osborne/A.Yamamoto/K.Sinram

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.*

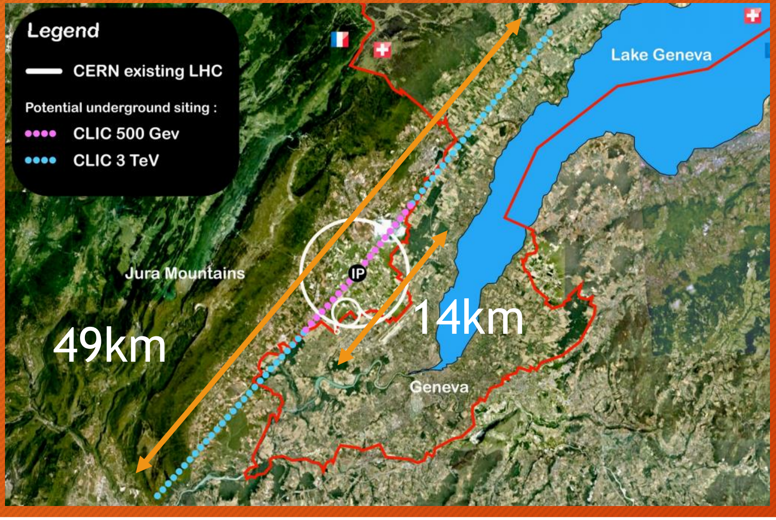
Meetings for the CEIS Working Group are taking place every 5 weeks to ensure full integration of the work done by each discipline.

Full Activity tracker updated at each meeting outlining the tasks for each discipline.

Status – CLIC CDR

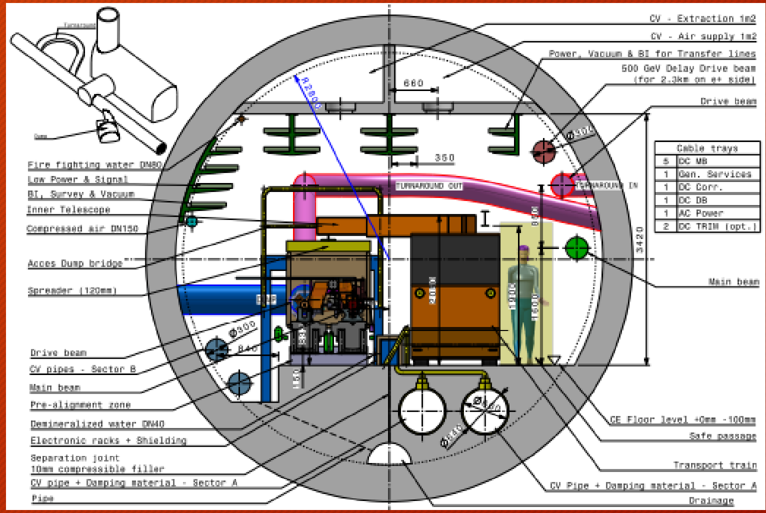
5.6m diameter 2 stage linear collider straddling the French & Swiss border:

- 500 GeV
- 3 TeV

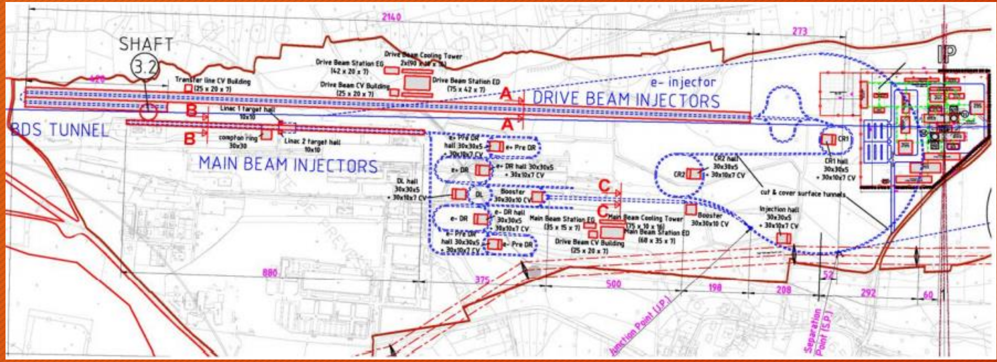


5.6m diameter main Linac to contain:

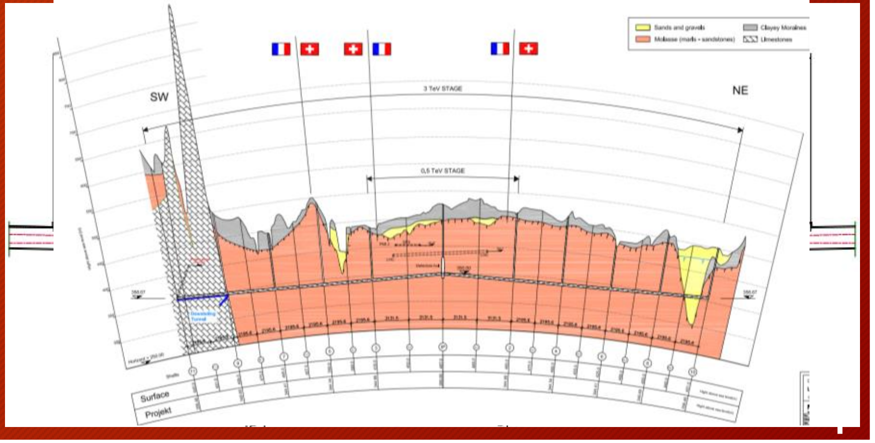
- Two beam accelerator and beam pipes
- Transport and safe walkway
- Air, water and electrical supplies
- Ancillary cables and ducts.



Central Injection Complex located on CERN land



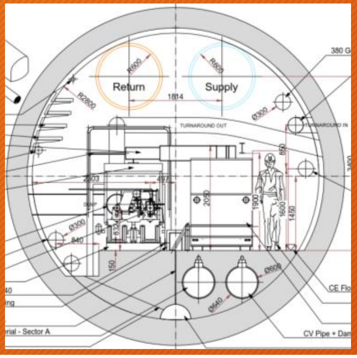
- 2 Independent Detector Caverns.
- Depth ranging from 100m to 150m along majority of length.

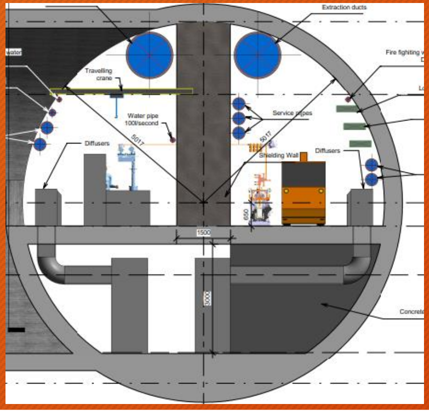


Current Status – Civil Engineering

Two options are considered in the PiP for Civil Engineering:

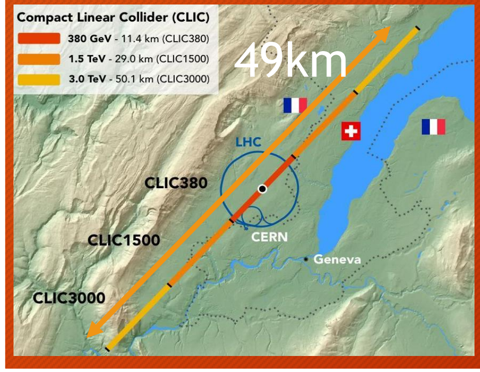
- Drive beam option with 5.6m ID.
- Klystron option with 10m ID.
  - TBM Excavation.

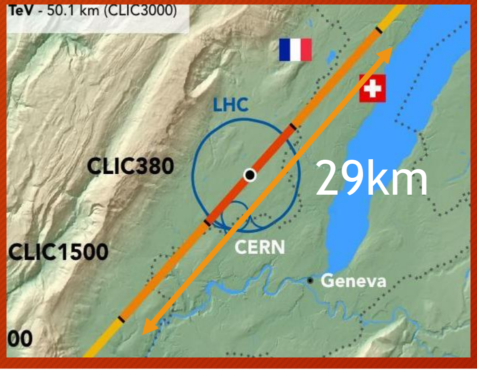


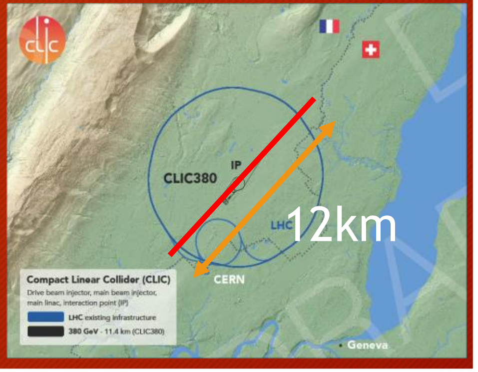


A **New 3 stage** Linear Collider proposed with 2 options the first energy stage of 380 GeV.

- Drive Beam options as proposed in the CDR and;
- A new Klystron option.



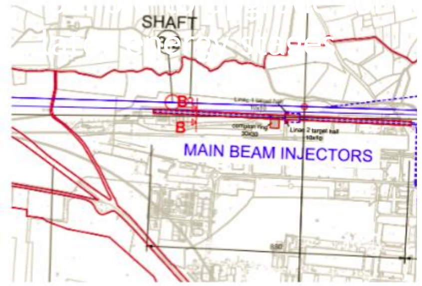


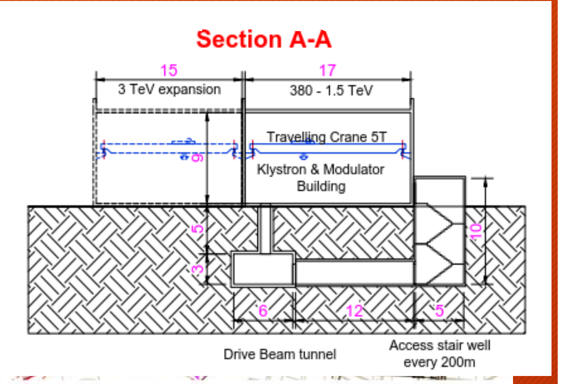


Surface sites optimised for 380 GeV DB Option:

Surface sites optimised for 380 GeV - Klystron Option:

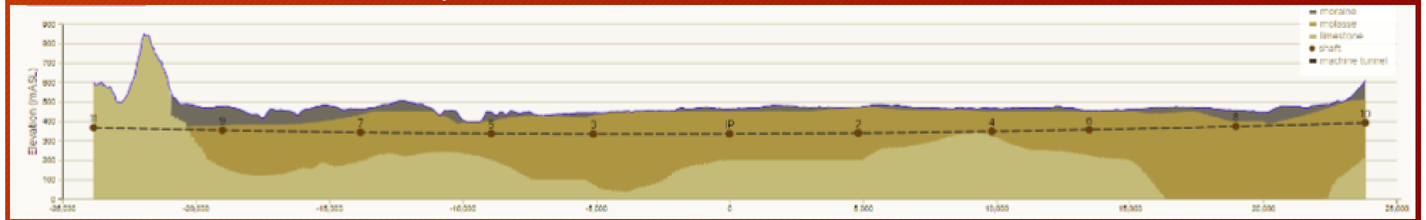
- Reduced drive beam building
- Klystron injection complex / injection facility.
- Possible to upgrade for





A **New alignment** option (using TOT) for an optimised 380 GeV machine has been proposed.

- 380 GeV machine with easy upgrade possibilities.
- Reduced overall shaft depth.



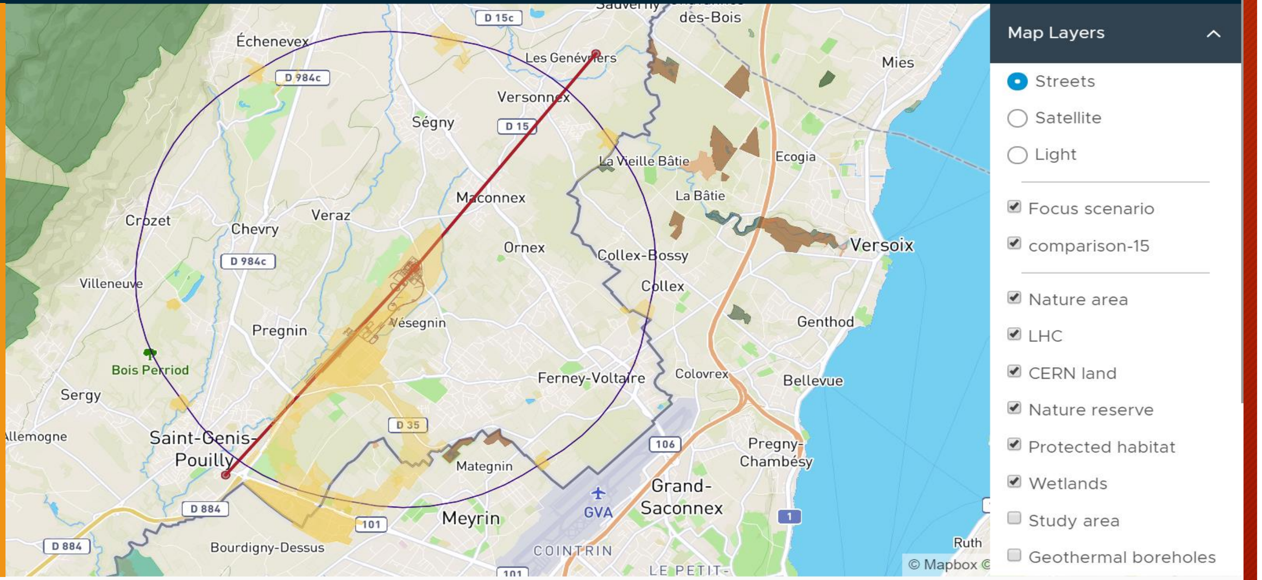
CLIC Tunnel Optimisation Tool (TOT)– Civil Engineering

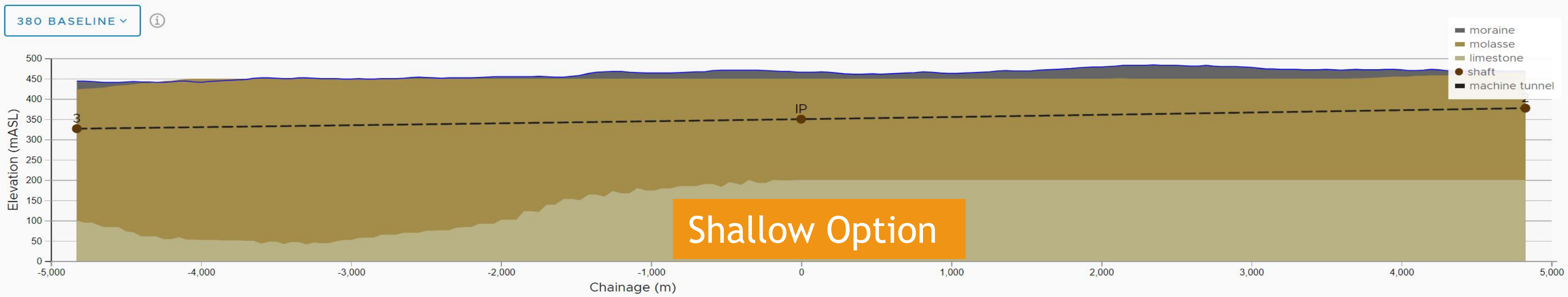
ARUP

Scenarios My Profile Log out

CLIC TOT Advantages

- Allows quick movement of the entire machine.
- Easier to find optimised locations.
- User can run through many positions quickly and efficiently.
- Simpler to find and compare new positions.

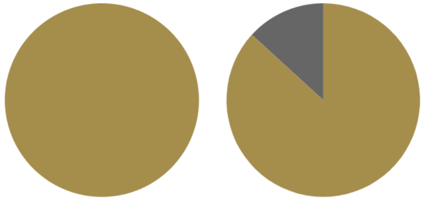




CLIC TOT- Civil Engineering

Focus: 380 Baseline

Tunnel	IP
Energy stage: 380 GeV	x: 2494510.09
Gradient: 0.3˚	y: 1125552.01
Created by: matthew.stuart	Elevation: 350mASL
Last edit date: 20/10/2017	



Total tunnel geology   Total shaft geology

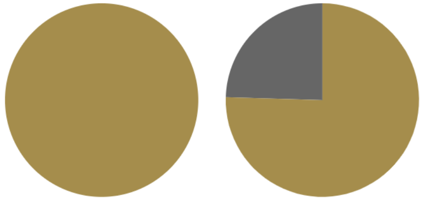
moraine   molasse
limestone

Shaft geology & length (m)

3: 117.44	
IP: 116.00	
2: 91.90	

380 shallow

Tunnel	IP
Energy stage: 380 GeV	x: 2494510.09
Gradient: 0.3˚	y: 1125552.01
Created by: matthew.stuart	Elevation: 400mASL
Last edit date: 20/10/2017	



Total tunnel geology   Total shaft geology

moraine   molasse
limestone

Shaft geology & length (m)

3: 67.44	
IP: 66.00	
2: 41.90	

380 GeV "CDR" Design

- Total Shaft Length: 325m
- Main Tunnel entirely in Molasse

380 GeV Shallow Option

- Total Shaft Length: 175m
- Main Tunnel still remains in the molasse

Focus: 380 Baseline

Natural feature overview (machine)

Under water body (%)	0.00
Nature area (%)	0.00
Protected habitat (%)	0.00
Wetlands (%)	0.00

Distance between shafts (m)

3-IP	4,826.84
IP-2	4,826.59

380 shallow

Natural feature overview (machine)

Under water body (%)	0.00
Nature area (%)	0.00
Protected habitat (%)	0.00
Wetlands (%)	0.00

Distance between shafts (m)

3-IP	4,826.84
IP-2	4,826.59

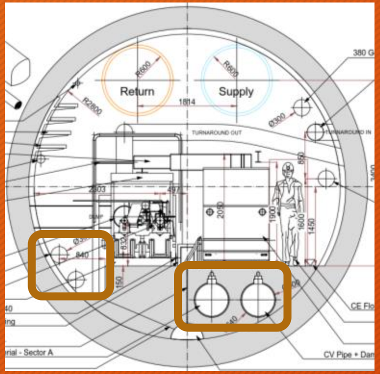
Current – Cooling and Ventilation

Air Conditioning

- 2 AHUs required per alcove (Redundancy?)

Cold Water Supply:

- AHUs (Alcoves + Tunnel)
  - Cooling towers (CT) only or CT + refrigeration cycle.
  - Pipes below the tunnel invert
- Accelerating Structure
  - CT only
  - Pipes running within the tunnel



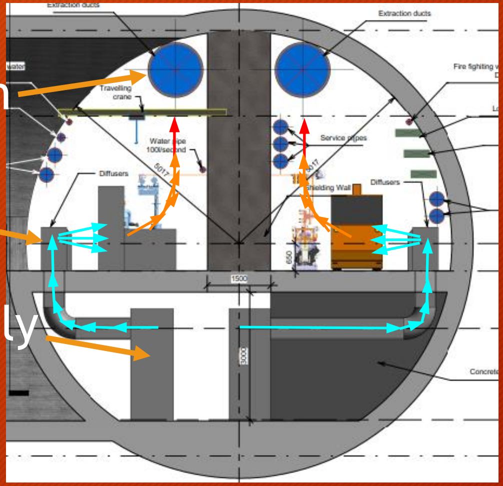
DB Main Tunnel

Air Conditioning

- Air is supplied and extracted in the tunnel via diffusers and extraction ducts
- Refrigeration units cool air before driving it to the diffusers
- Ambient Temperature of the tunnel set at 28 degrees

Cold Water Supply:

- AHUs (Alcoves)
  - Cooling towers only or cooling towers + refrigeration cycle.
- Refrigeration units and Accelerating structures
  - CT only



Klystron Main Tunnel

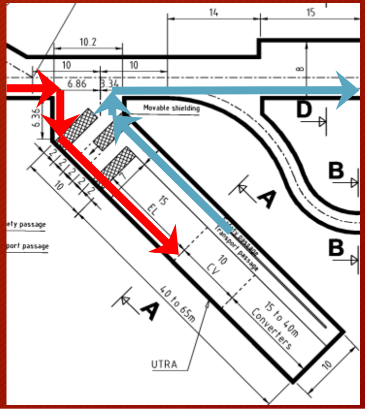
Concerns

- Not all required data is available (ex. Heat loads alcoves)
- Fire doors and fire compartments to be determined for both options.

Next Steps for both options:

- Investigate the heat loads in the alcoves & surface buildings
- Suitable CV design for the BDS.
- Integration with civil engineering Alcoves

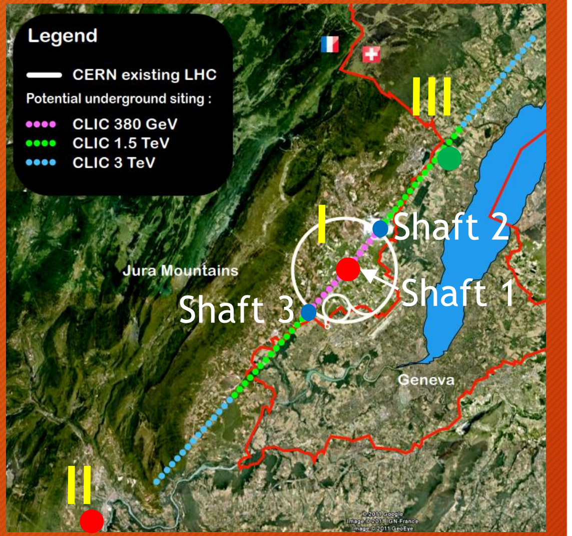
CV ducts to enter and exit the UTRA's every 878m



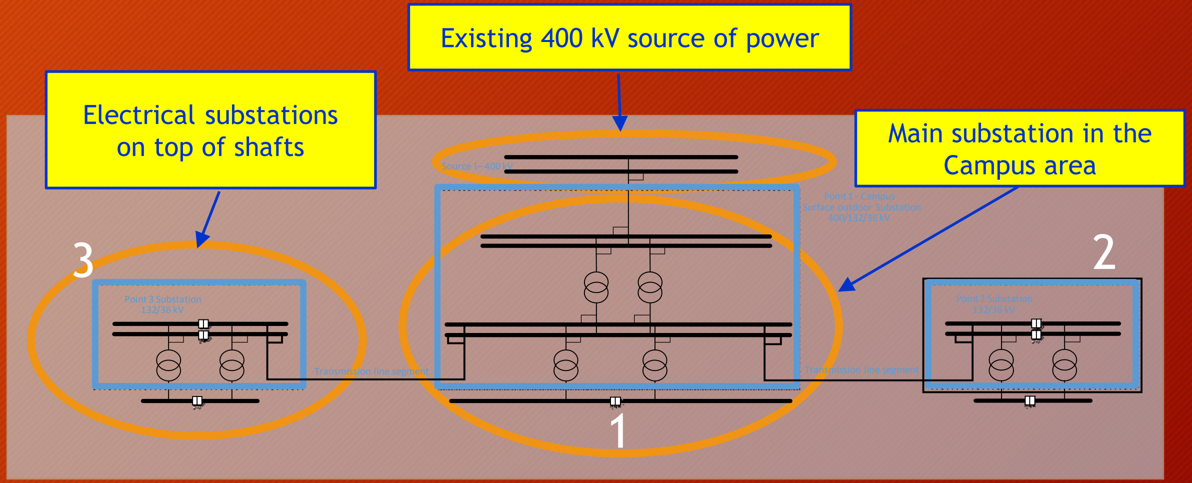
Current Status – Electrical Infrastructure

Electrical Power Supplies for CLIC 380 GeV – 3 TeV:

- Two 400kV supplies located at point I and II in France.
- One 230kV supply located at point III in Switzerland
- Necessary power requirements for CLIC are already available – no upgrades of the European grid required.



- Power supplied from the 400kV European grid to the main campus substation
- Main campus substation connects to points 2 & 3 through a 135kV transmission line



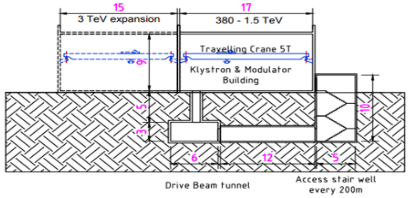
The necessary power supply for each of the four CLIC configurations is available, therefore, no upgrade or extension of the European Grid is required.

Current Status – Transport and Handling

Significant changes in the drive beam option:

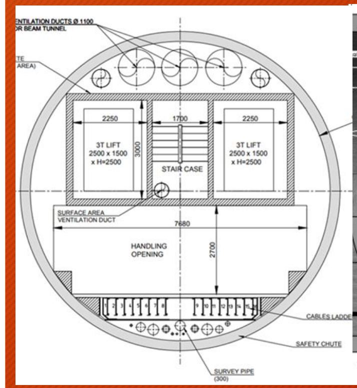
- Shaft design (2 lifts now)
- No. of transported modules.
- Integration of Transport and DB Injector building
- Cranes for surface buildings

Building Type:	Crane load capacity (tonnes)
• Detector Assembly	2x80 (CMS approach) + strand jacks
• Cooling Tower and Pump Station	3.2
• Cooling and Ventilation	20
• Cryogenic Warm compressor	20
• Cryogenic Surface Cold Box	20
• Workshop	10
• Central Area Machine Cooling Towers	5
• Shaft Access	20
• *Drive Beam Injectors*	*5x5 for 380 GeV*

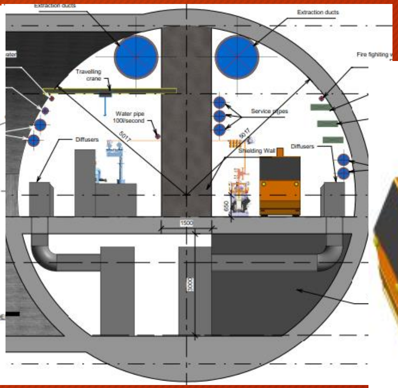


Transport requirements and updates for the Klystron design:

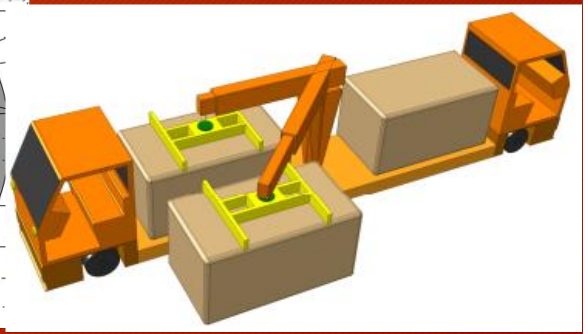
- Main tunnel transportation methods – bespoke transport vehicle for modules.
- Installation of transported Accelerating structure, Lifting arm of vehicle
- Transport options for maintenance of klystrons, crane or standard vehicles?
- Cranes for surface buildings



Shaft



Klystron Main Tunnel



Next Steps

- Study machine and solenoid installation for the Klystron option.
- Continuously update the equipment tables for the Klystron and DB options.
- Produce a complete list of all the buildings that require cranes.

Concerns

- Equipment dims and weights inside the DB injector buildings not defined.
- Space constraints in the klystron option – specifically the klystron side of the tunnel

Current Status – Safety Systems

A detailed safety strategy was produced for the CLIC CDR, therefore, the PiP for safety systems has focussed on the identification of hazards in the below area:

5 Safety Systems

5.1 Mechanical Hazards

5.2 Chemical Hazards

5.3 Fire Safety

5.4 Environmental Hazards

5.5 Electrical Hazards

5.6 Biological Hazards

5.7 Non-Ionising Radiation Hazards

5.8 Workplace Hazards

5.9 Structural Safety

Next Steps

A hazard register has been drawn up to categorise all hazards:

- Live document to be updated throughout the lifecycle of the project.
- Identify which hazards require further mitigation.
- Study into the environmental impact of surface cooling towers.

Concerns

Fire safety within the klystron tunnel needs to be reviewed, new CV solution as well as klystron modules within the tunnel.

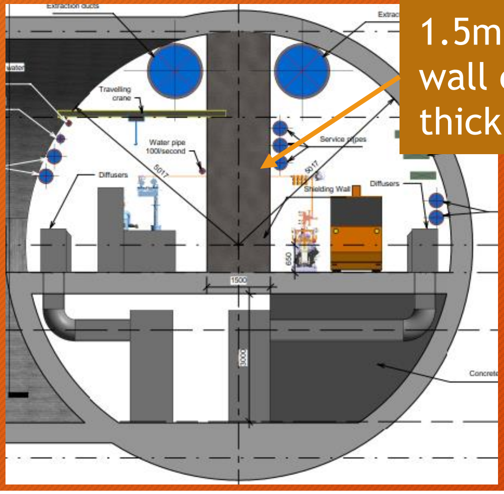
- Fire safety for the Klystron design requires further study due to the large quantities of oil located in the tunnel
- New CV solution needs integrating with fire safety compartments.

Current Status – Radiation Protection

Note: Minimal changes to the drive beam option

For the radiation protection aspects of the klystron option the PiP has considered the following:

- Klystron gallery running parallel to the main tunnel.
- Gallery to remain accessible under certain operational conditions.
- Minimum shielding required for radiation protection during access, driving factor is the dark current.



1.5m thick shielding wall currently assumed thickness – based on ILC

Next Steps

- Thickness of the shielding wall still needs to be confirmed if the galleries are to remain accessible under certain operational conditions.
- Identify the accessibility and RP requirements for the klystron design.
- Air activation to be studied to understand its contribution to the radiological environmental impact.
- Evaluation of the activation of water in the closed water cooling circuits (not a major concern)

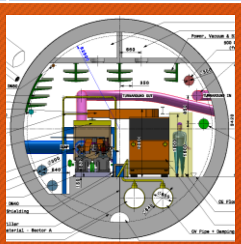
Concerns

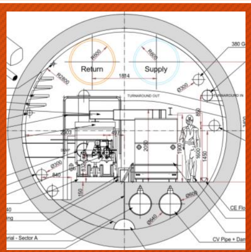
- Study into the dark current generated is necessary to determine the exact shieling requirements.

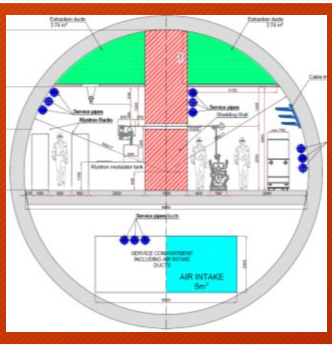
Cost Estimate – Civil Engineering

	CDR 500 GeV (CHF)	New 380 GeV Drive Beam (€)	Klystron 380 GeV TBM 10m (€)
Underground Structures	704,673,823*	587,986,135**	884,821,974**
Surface Structures	639,677,291*	218,898,945**	124,898,285566**
Cut & Cover tunnels	Included in "Surface Structures"	131,501,222**	50,834,281**
Site development	88,031,164*	Included in above costs	Included in above costs
Total	1,432,382,278*	938,386,302**	1,060,554,540**
Tunnel Length (km)	14	12	11.6

*Rates for CHF taken from 2010
**Rates for Euros taken from 2016
***This value is for site development







Drive Beam Uncertainties:

1. Shielding wall cost within the Caverns needs to be added to total Cost.
2. CV Ducts could still effect the tunnel cross-section/dia.
3. BDS Cavern and BC2 Caverns need defining.

Klystron Uncertainties:

1. Shielding wall separating the tunnel is based on ILC and could change (currently estimated at 30m Euros).
2. CV Ducts could still effect the tunnel cross-section/dia.
3. An update will be required to include the access points at each UTRC for the services compartment. (could be significant cost increase)
4. More work to be done on the Tunnelling cost for a 10m ID tunnel.

Cost Estimate – Transport and Handling

Estimate for cranes, lifts, industrial equipment, operation		
Item	3 TeV Costs (CHF)	380 GeV costs (CHF)
Cranes	21,945,000	13,050,000
Hoists	180,000	40,000
Lifts	6,400,000	2,400,000
Reception	100,000	53,000
Spares	2,500,000	1,330,000
Consumables	700,000	370,000
Fork lifts, trucks , trailers	20,000,000	15,000,000
Maintenance	2,750,000	730,000
Operation	37,800,000	19,000,000
Sub total	95,675,000	51,973,000

Standard equipment Total: 51,973,000

Difference in price for 380 GeV and 3 TeV

- Injection + experiment surface buildings
- Less spares and maintenance for 380GeV
- Reduced vehicle guidance lines and power rail for 380GeV
- Fewer shaft cranes, lifts, hoists for 380GeV
- Fewer manpower costs for machine operation at 380GeV

Total Cost 380 GeV: 91.273.000 CHF

Estimate for special tunnel equipment (studies etc)		
Item	3 TeV Costs (CHF)	380 GeV costs (CHF
Integration studies and project r	800,000	800,000
Mock up zone, tests and training	800,000	800,000
Independent inspections	100,000	100,000
Spares	3,500,000	3,200,000
Maintenance	3,500,000	3,200,000
Sub total	8,700,000	8,100,000

Special tunnel Prelim. studies Total: 8,100,000

Estimate for special tunnel equipment (equipment purchases)		
Item	3 TeV Costs (CHF)	380 GeV costs (CHF
Vehicles	17,000,000	17,000,000
Unloading/ transfer equipment	9,000,000	9,000,000
Power rail	5,500,000	1,500,000
Special adaptations for services	6,000,000	3,000,000
Guidance infrastructure	3,500,000	700,000
Sub total equipment	41,000,000	31,200,000

Special tunnel equipment Total: 31,200,000

Cost Estimate – Electrical Infrastructure

Total Cost for 380 GeV Electrical Infrastructure: 235,440,000 CHF

Level	Element	Material		Labor		
		Quantity	Total cost (k€)	Cost (k€/hour)	Cost (k€)	Total cost (kCHF)
1	Connection to EU grid	2.0	6,000	Turnkey	-	7,200
1	Connection EU grid to CLIC point	21.7	17,040	Turnkey	-	20,448
1	Incoming EHV-HV substation	3.0	45,182	Turnkey	-	54,219
1	Transmission line	11.4	3,805	0.06	766	5,485
1	HV-MV substation	7.0	39,485	Turnkey	-	47,382
1	Back-up source	3.0	5,473	Turnkey	-	6,568
1	Diesel generator system	3.0	9,450	Turnkey	-	11,340
1	UPS system	6.0	5,622	Turnkey	-	6,746
1	Surface main substation (MV & LV)	3.0	11,133	Turnkey	-	13,360
1	Surface distribution network (MV & LV)	3.0	6,770	Turnkey	-	8,124
1	Surface buildings electrical infrastructure	3.0	688	Turnkey	-	826
1	Underground distribution network (MV)	14.0	3,080	0.06	605	4,422
1	Tunnel electrical infrastructure	11.4	17,610	0.06	492	21,723
1	Injectors electrical infrastructure	6.0	11,742	0.06	259	14,401
1	Experimental area electrical infrastructure	1.0	2,717	0.06	43	3,312
1	Alcove UTRA	6.0	2,896	0.06	346	3,889
1	Alcove UTRC	3.0	1,433	0.06	173	1,927
1	Technical shaft electrical infrastructure	0.6	2,922	0.06	35	3,547
1	Experimental cavern infrastructure	1.0	217	0.06	216	520
	Total		193,265		2,935	235,440
	Currency exchange factor (€/CHF) 1.2					

Concluding remarks

- This is a conceptual budget estimate
- Account at this stage for -20/ +50 % cost variation
- Same budget estimate for 380 GeV for Klystron and DB
- Prices subject to exchange rate and material (CU and AL) market price fluctuations
- No design costs are included here (approx. 8-10%)

- New Infrastructure required for the 1.5 and 3 TeV stages and;
- Increase in power supply from the substation on CERN campus.

Project Implementation Plan Summary

Chapter	Discipline	Pages	Comments	Responsible person	PiP Status		Cost Status	
CEIS								
	Civ. Eng	5	Pages increased to 5 for CE	John Osborne/Matt Stuart	Completed	☺☺	First Estimate	☺
	Electicity supply	3		Davide Bozzini	Word doc. reviewed	☺☺	First Estimate	☺
	CV	3		Mauro Nonis	Subheadings received	😐	Not Received	☹
	Transport and Installation	3		Ingo Ruehl/Michael Czech	Word doc. reviewed	☺☺	First Estimate	☺
	Safety systems	3	incl. enviroment and access	Simon Marsh	Word doc. reviewed	☺☺	Not Received	☹
	Radiation studies	3		Markus Widorski	Word doc. reviewed	☺☺	**N/A**	
	~~Cryo~~	3	~~in case of SC solenoid, check~~	~~Dimitri Delikaris~~	~~NA~~		~~N/A~~	

Remarks

1. Next review date for the PiP is towards the end of June, complete draft required by the 15th of June 2018.
2. Final draft by the 31st of August 2018 to allow executive summary to be prepared.
3. Final ESU submission by the 18th of December 2018.
4. Internal Cost Review on the 26th of June 2018.

Conclusion

Next Steps CEIS Working Group

- Integration studies for the C&V and tunnel alcoves to be completed.
- Ongoing siting of the machine to find optimal position of CLIC.
- Cooling and Ventilation studies to be completed for machine buildings and tunnel alcoves.
- RP Studies to be concluded to understand the protection requirements for CLIC
- Fire safety for the Klystron option to be optimised.

Remarks and upcoming milestones for 2018

1. Next review date for the PiP is towards the end of June, complete draft required by the 15th of June.
2. Final draft by the 31st of August to allow executive summary to be prepared.
3. Final ESU submission by the 18th of December.
4. Internal Cost Review on the 26th of June.