CLIC Civil Engineering Update

Matthew Stuart – John Osborne SMB-SE-FAS

Reminder – Summary From 05/05/2017

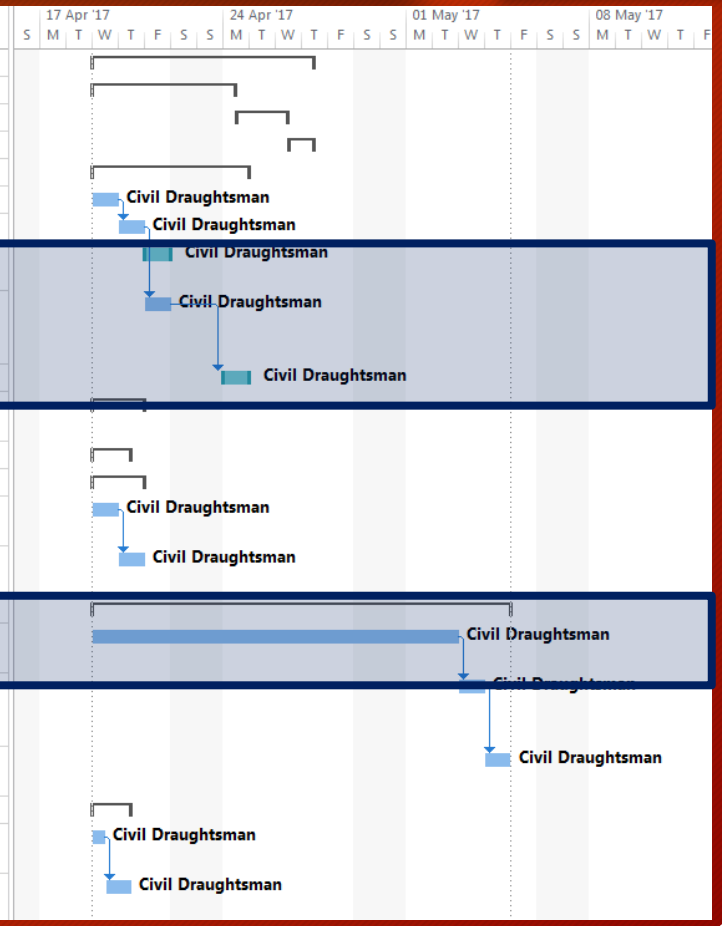
- Cooling and Ventilation solutions essential to allow a feasible cross section to be produced.
- Transport options to be explored.
- Continue CLIC-TOT development – Task 3 & 4. Data Integration and Initial Draft Version to be Produced for Testing).
- Produce 3D schematic of the “baseline CLIC machine”.
- A detailed cost estimate for infrastructure to be produced and work together with ILC on areas of synergy.

Civil Drawing Update

Updates:

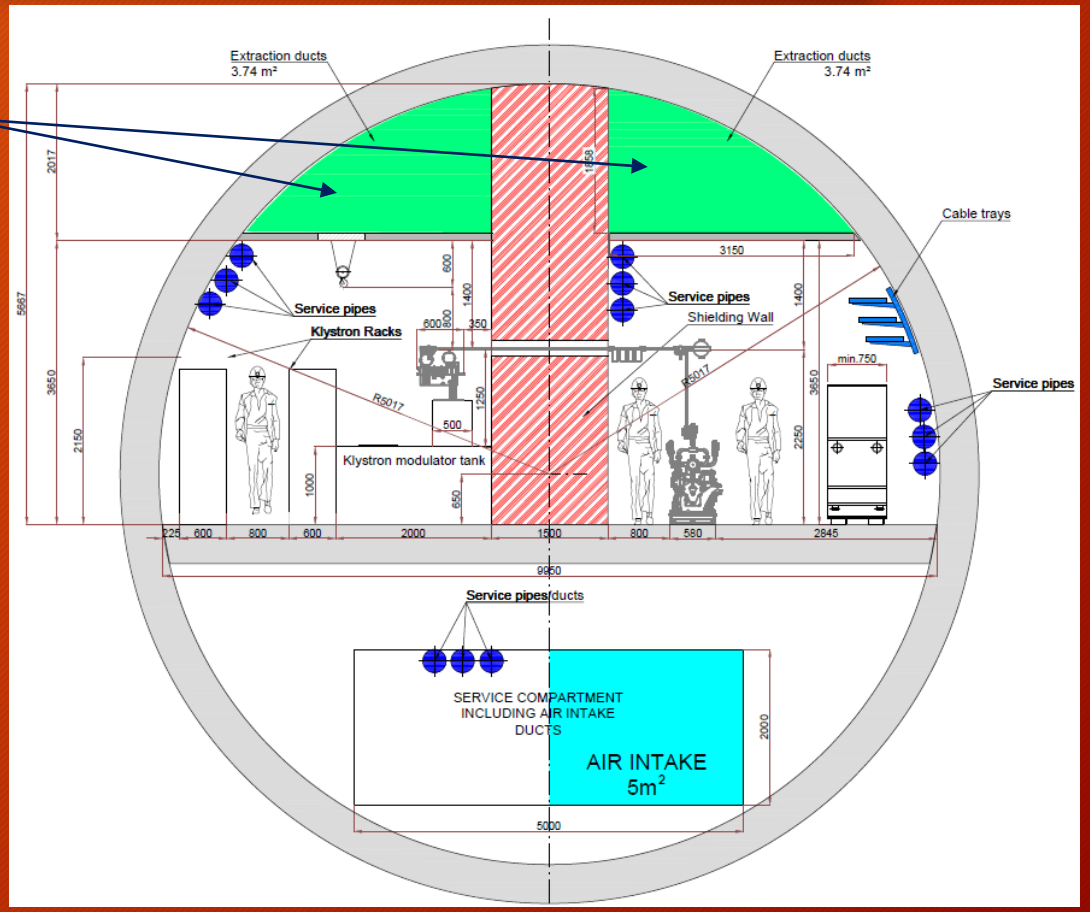
- General Cross-section update for the Klystron Design.
- Klystron Injection Complex surface buildings layout Layout.
- Shaft Cross section for Klystron Installation.
- Initial Conceptual 3D Schematic produced for CLIC.

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	
	Klsystron Shaft Layout	1 day	Mon 24/04/17	Mon 24/04/17	18	Civil Draughtsman	
	Cross-Sections)						
	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	
	(Including all caverns/shafts)						
	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	



Klystron Single Tunnel - TBM

Extraction located above false ceiling



TBM Tunnel

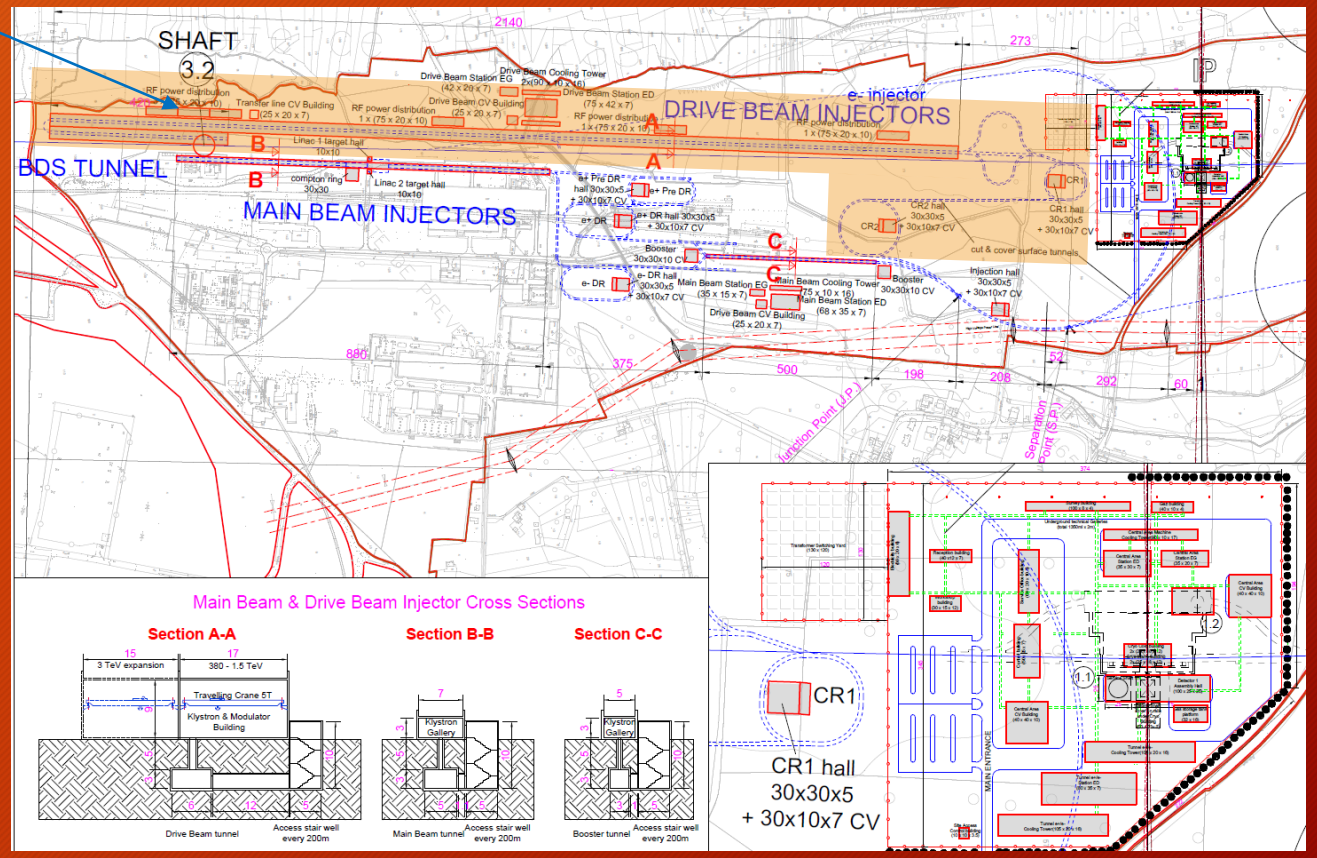
- Preferred option is the 10m ID single tunnel TBM option.

Klystron Surface Buildings

Removal of drive beam complex.

Updates:

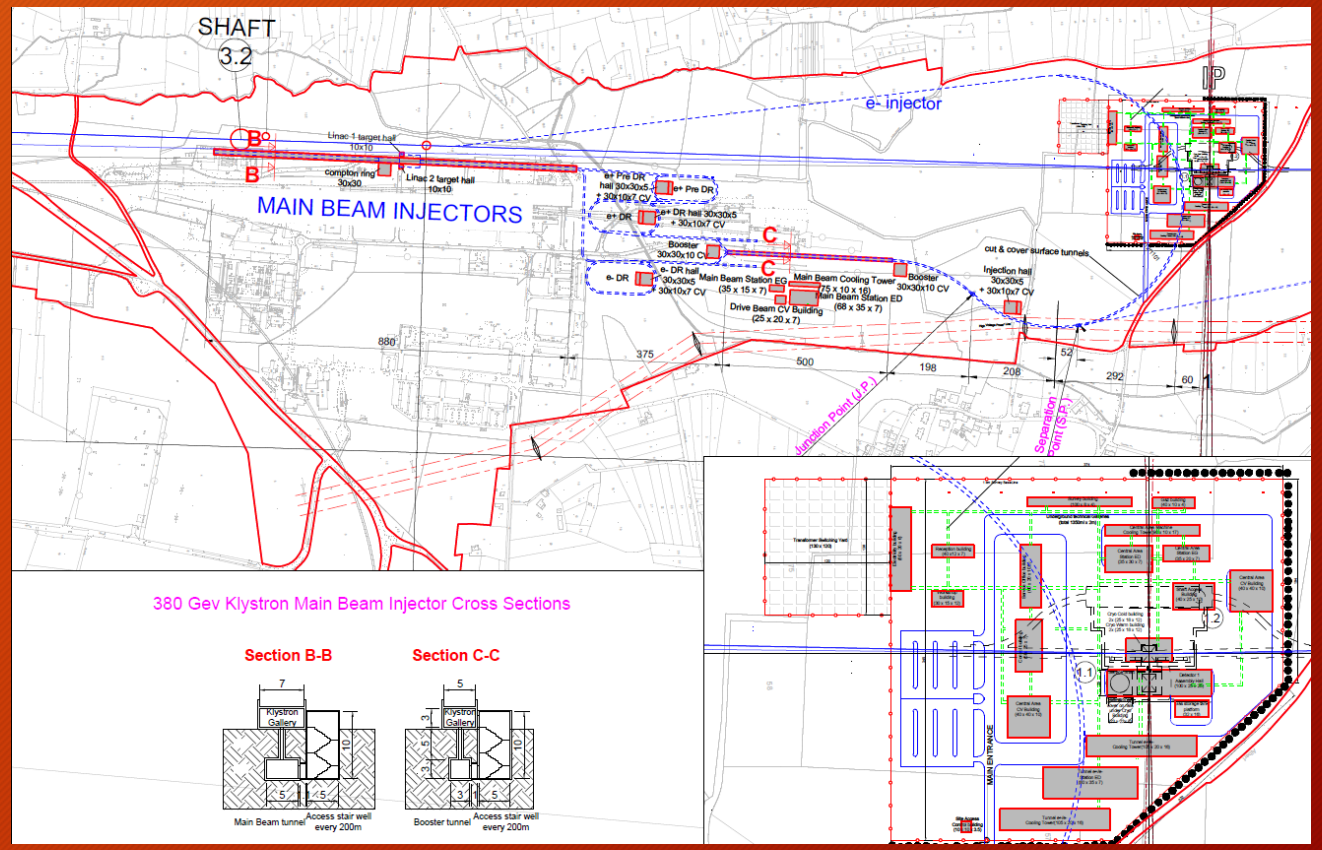
- For a Klystron 380 GeV Design the Drive Beam Complex is no longer required.
- Removal entirely of the 2.5km building and all associated cut and cover tunnels.



Klystron Surface Buildings

Updates:

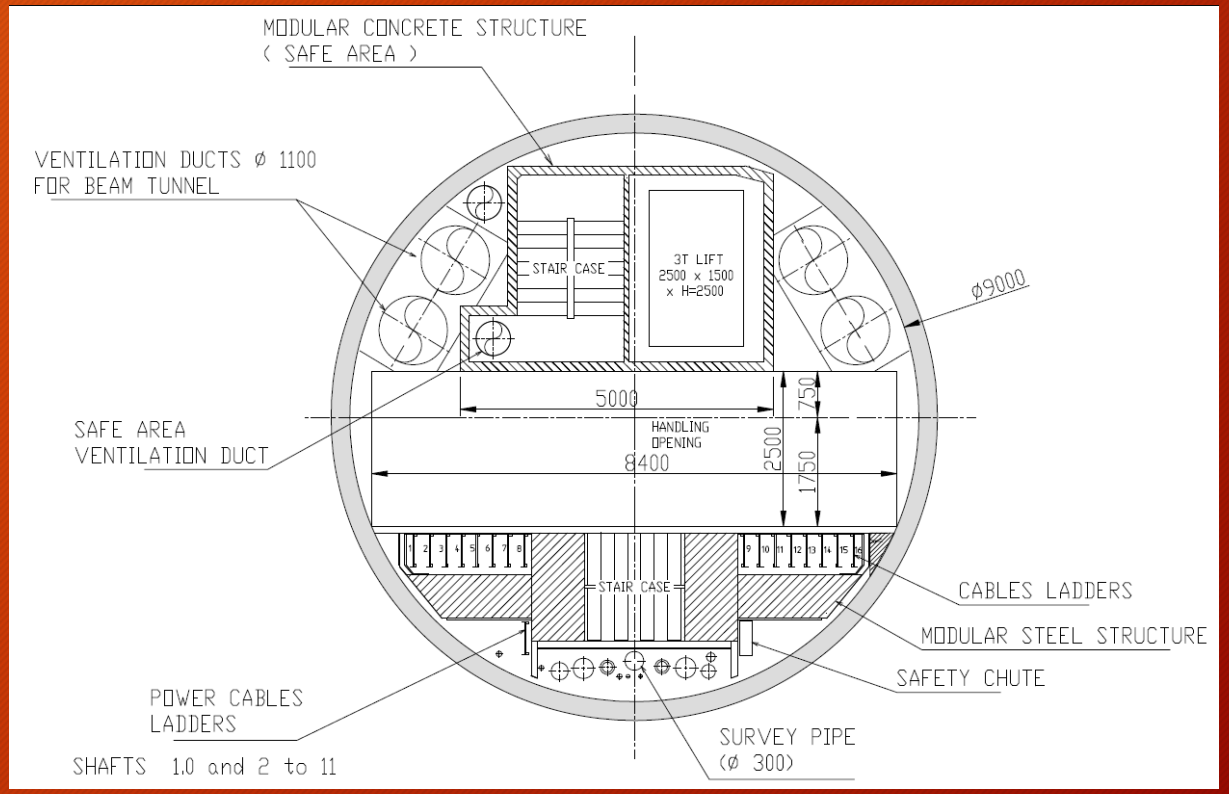
- For a Klystron 380 GeV Design the Drive Beam Complex is no longer required.
- Removal entirely of the 2.5km building and all associated cut and cover tunnels.



Civil Shaft Update

Updates:

- Initial Shaft has only one lift and two stair cases.
- To adhere to safety requirements and be consistent with FCC two lifts and one stair case is proposed.
- Updated Cross-section – allows access to both lifts from staircase.



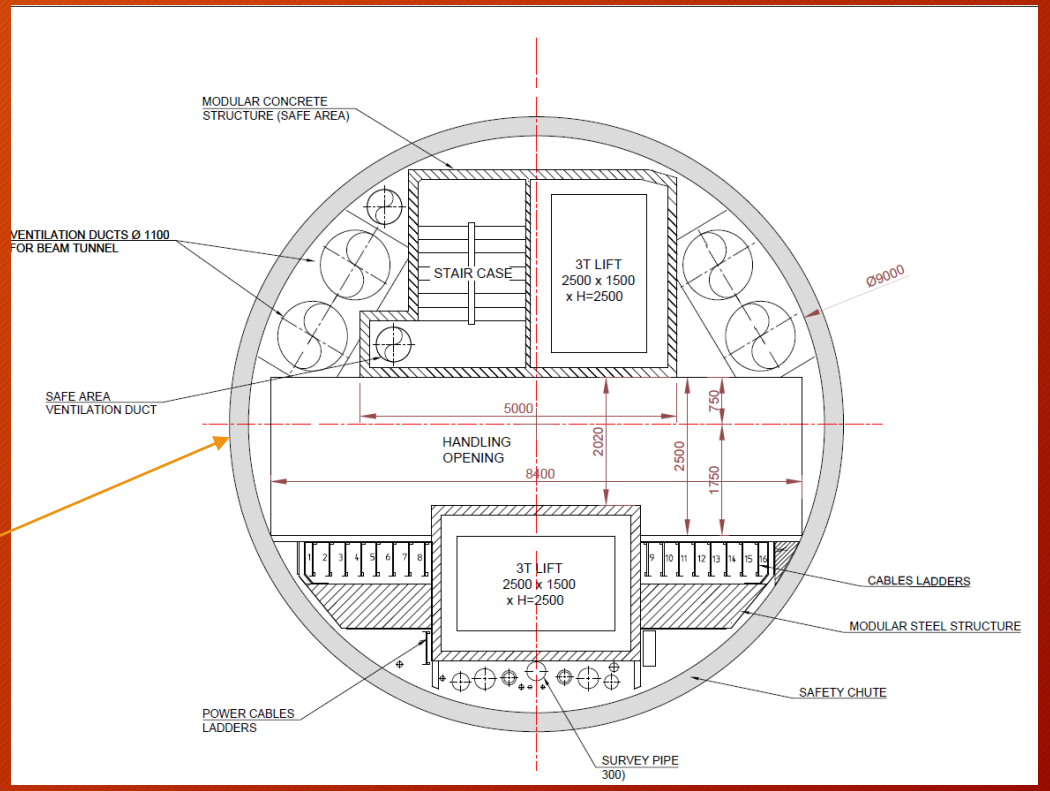
Shafts 1.2 and 2 to 11.

Civil Shaft Update

Updates:

- Initial Shaft has only one lift and two stair cases.
- To adhere to safety requirements and be consistent with FCC two lifts and one stair case is proposed.
- Updated Cross-section – allows access to both lifts from staircase.

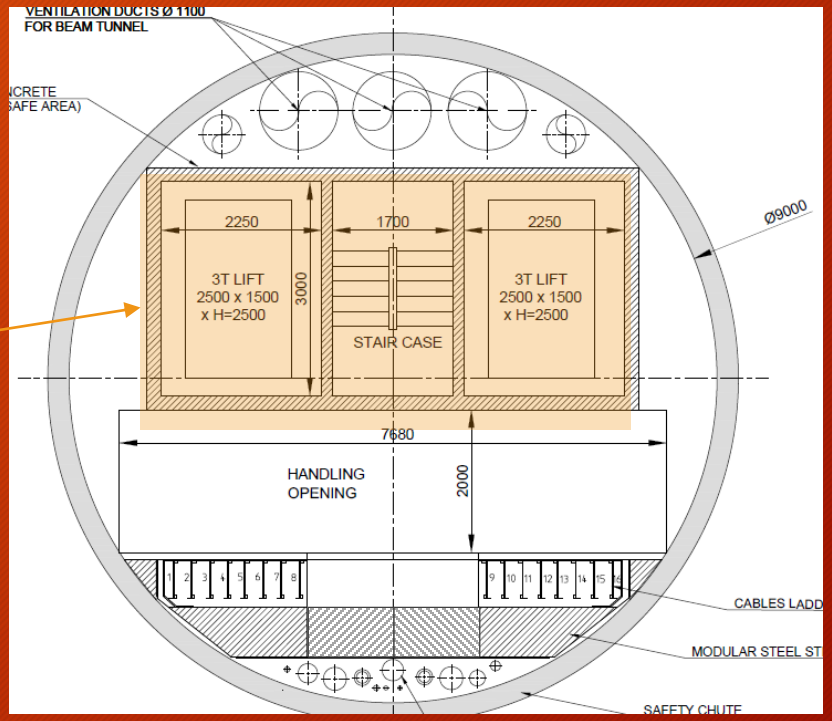
Previous Cross-section shown on the 21st of July.



Civil Shaft Update

Updates:

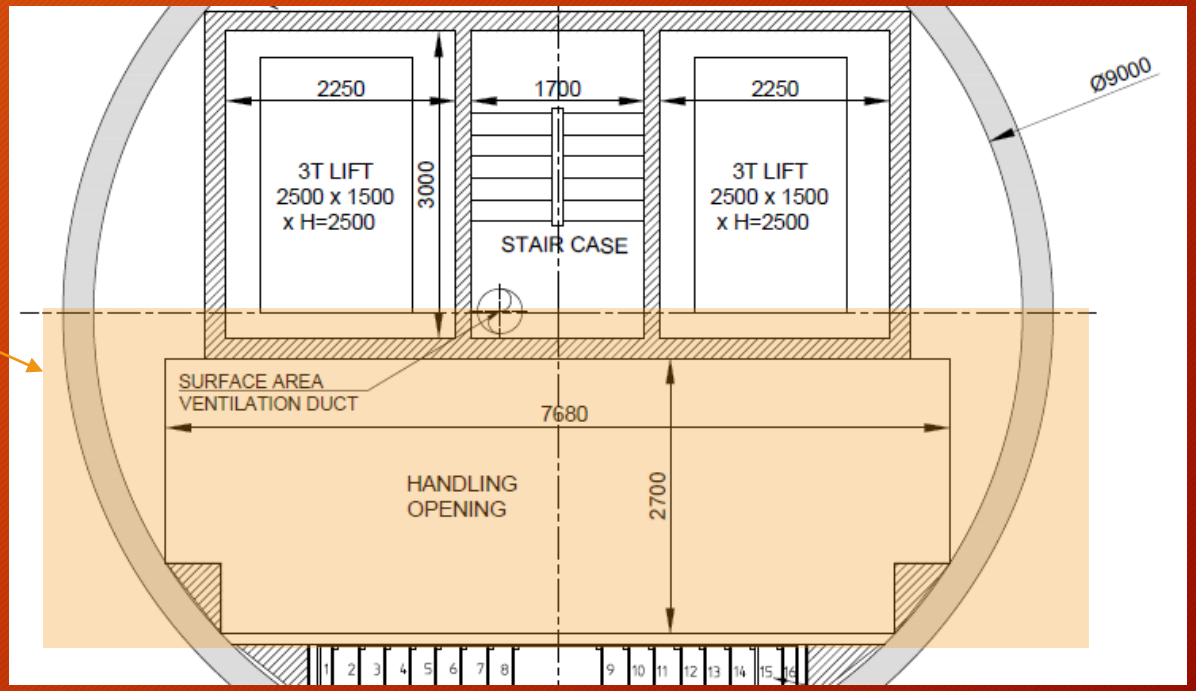
- Initial Shaft has only one lift and two stair cases.
- To adhere to safety requirements and be consistent with FCC two lifts and one stair case is proposed.
- Updated Cross-section – allows access to both lifts from staircase.



Civil Shaft Update

Remaining Questions:

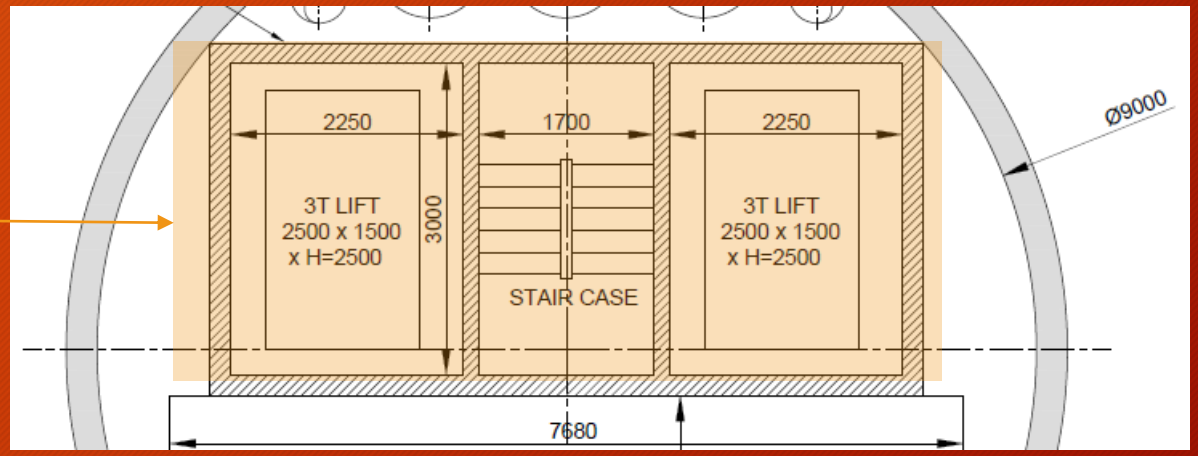
- Is the new dimensions of the handling open adequate?
- Are the lift dimensions and capacities adequate?
- Services within the shafts still need confirmation including ventilation.



Civil Shaft Update

Remaining Questions:

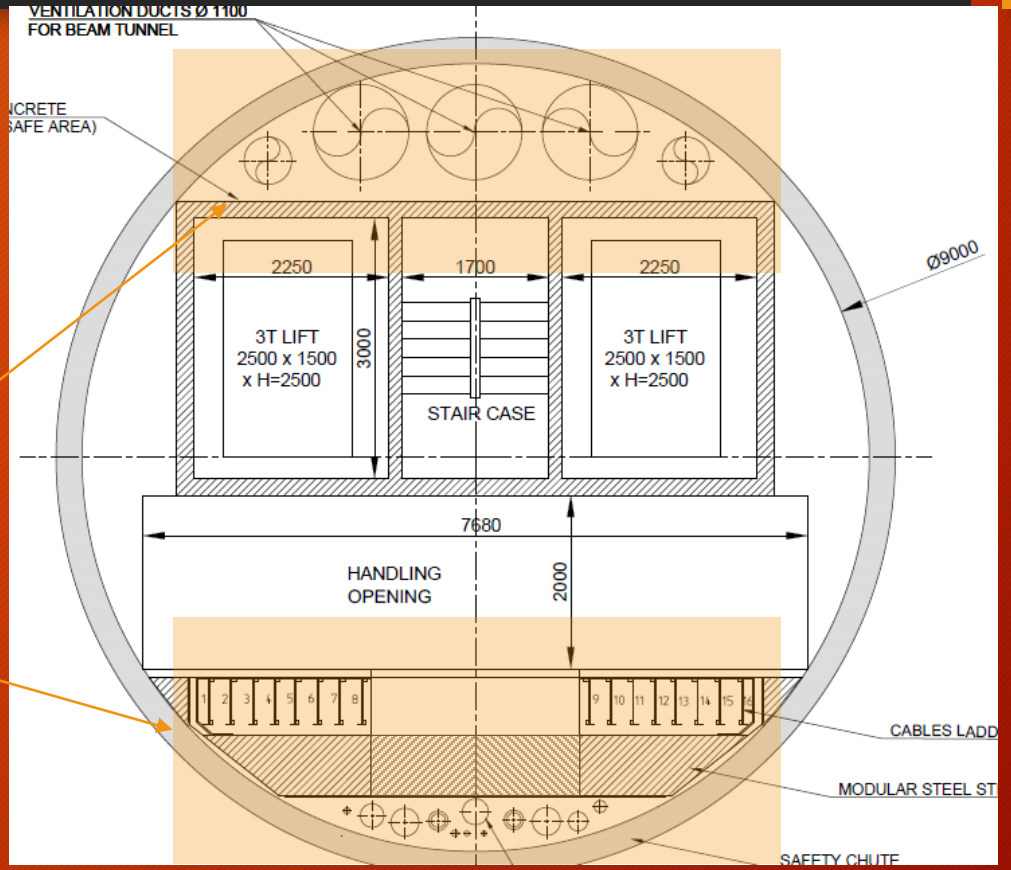
- Is the new dimensions of the handling open adequate?
- Are the lift dimensions and capacities adequate?
- Services within the shafts still need confirmation including ventilation.



Civil Shaft Update

Remaining Questions:

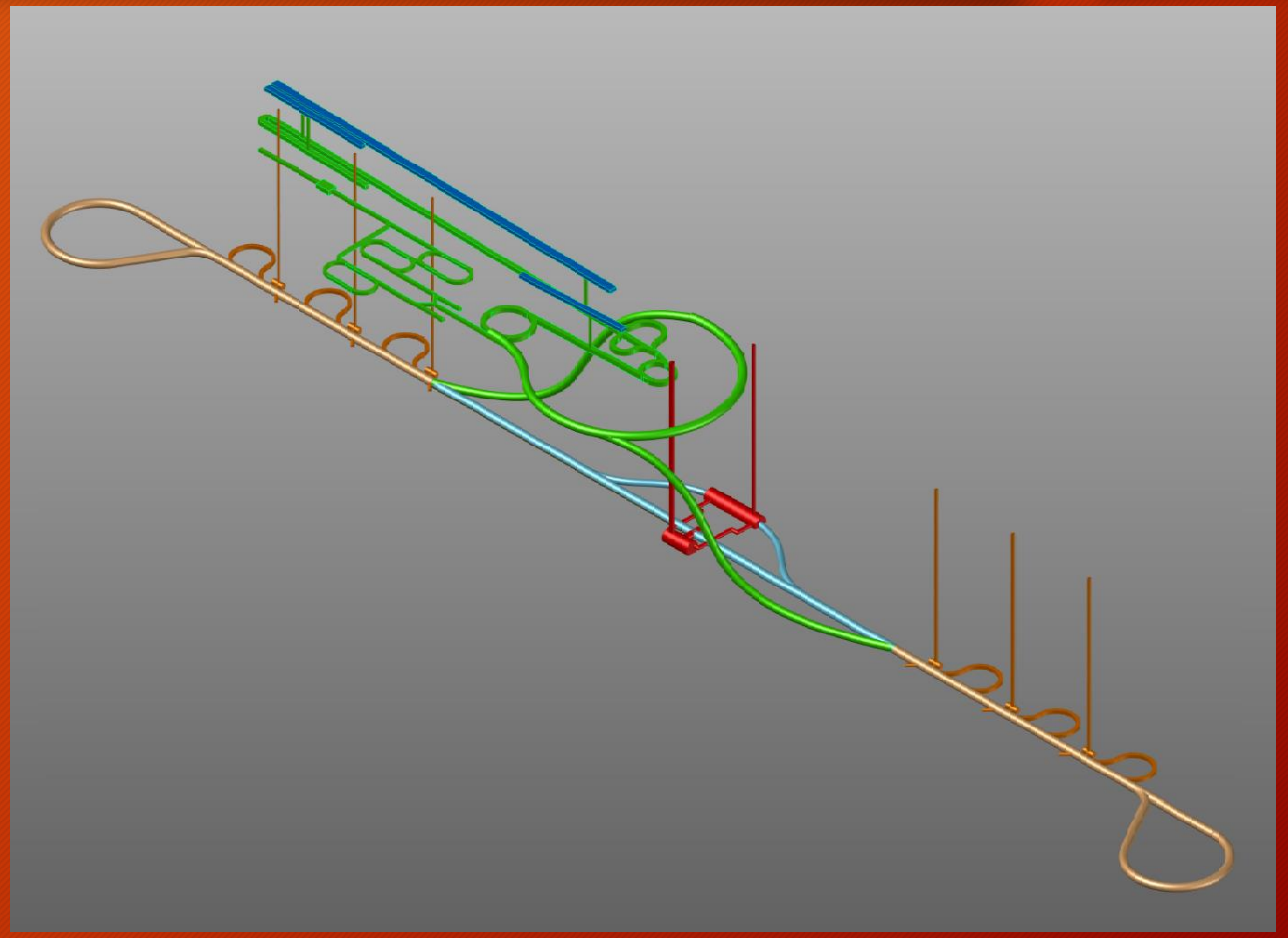
- Is the new dimensions of the handling open adequate?
- Are the lift dimensions and capacities adequate?
- Services within the shafts still need confirmation including ventilation.



380 GeV CLIC 3D Schematic

3D Schematic.

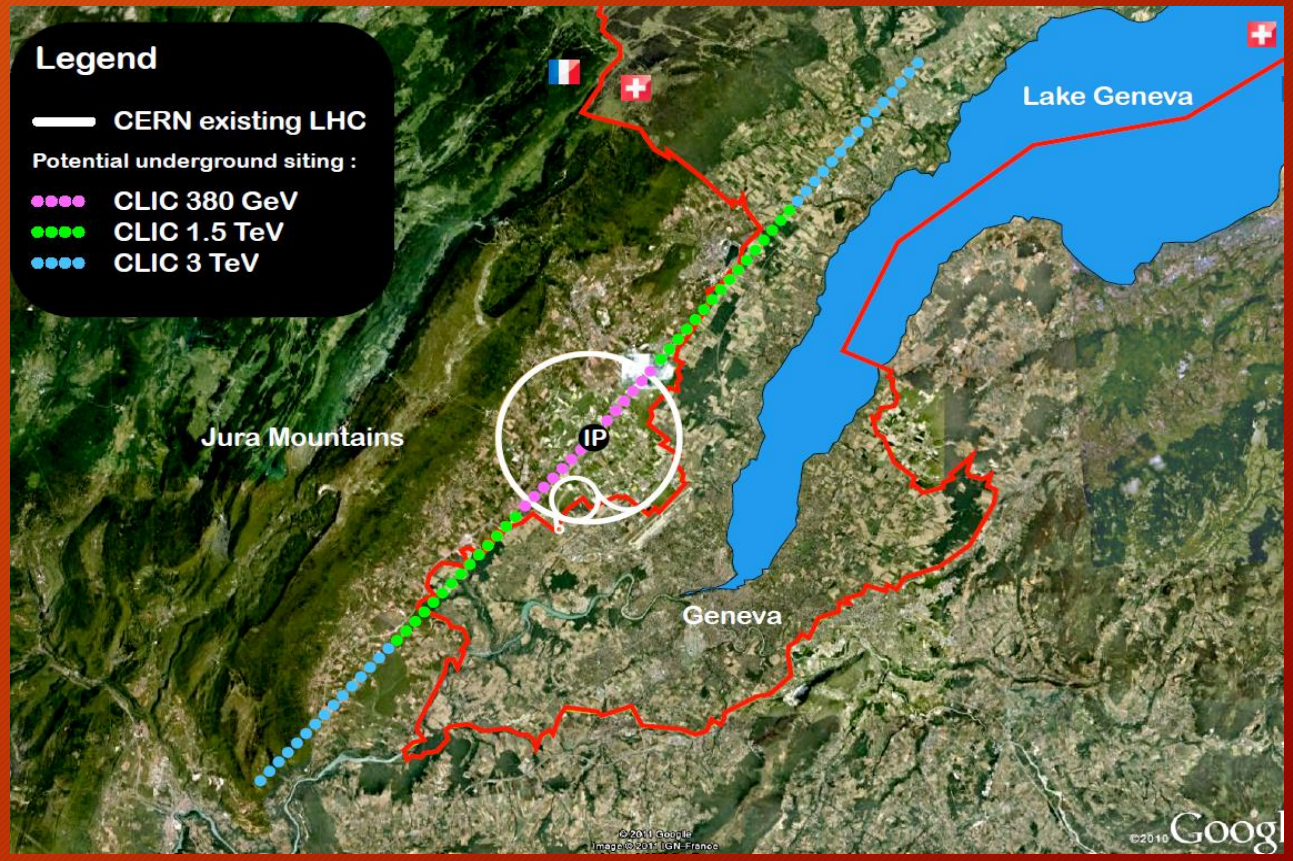
- This schematic has exaggerated some elements of the design for visual clarity.
- It is still under development and any feedback is welcome!



CLIC-TOT - Reminder

Reminder from the last update

- Datasets are to be acquired and defined, this includes:
  - Surface Topography.
  - Surface Constraints e.g. Buildings and roads.
  - Protected Areas.
  - Hydrological Data.
- Produce Lattice Files for baseline design.
- Develop User Interface For the CLIC TOT.
- Geological layer showing top of molasse and top of limestone.



TOT Timeline

The proposed programme task completion dates are as follows, assuming a project commencement at the end of April 2017:

Task 1	**Establish Project Setup and Technical Basis**
Task 2	**Data and Functionality Prioritisation**
Task 3	**Specifications and TOT-CLIC architecting/wireframing (Concept Stage)**
Task 4	**Data Integration and TOT-CLIC (beta) development** **Initial TOT-CLIC beta version**
Task 5	**Finalised TOT-CLIC Development**
Task 6	**Troubleshooting and Technical Support**

Data Integration

Data Integration:

- Completed:
  - Surface Elevation Model for the CLIC study area
  - Surface Constraints for the CLIC study area.
  - Geological Study area, top of molasse and limestone.
  - Protected area prioritisation within the CLIC Study areas
- Ongoing:
  - Lattice Files – Initial 380 GeV has been produced, however, further lattice files for the 1.5 TeV and 3 TeV energy stages will be required for the final version of the tool.

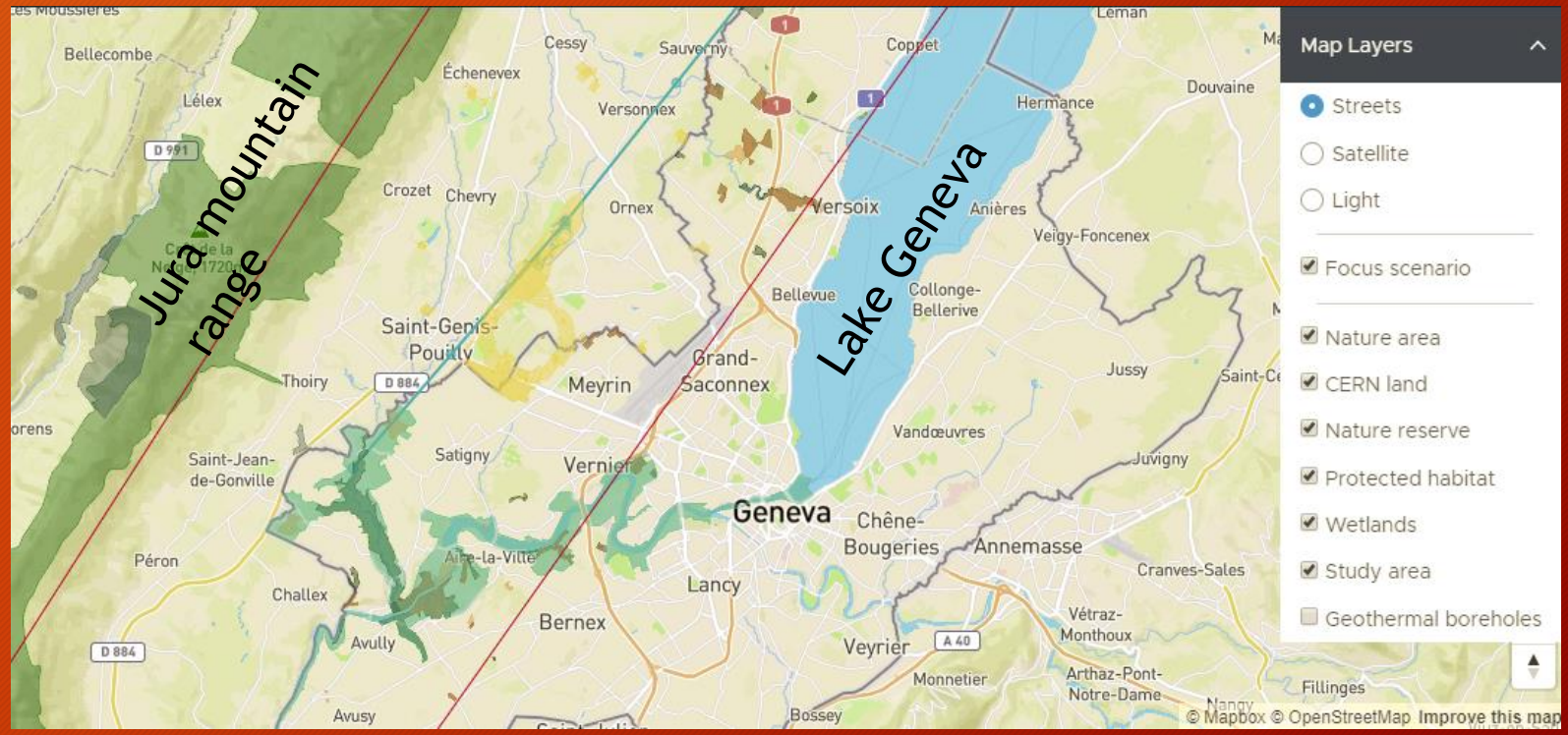
Task 1	**Establish Project Setup and Technical Basis**
Task 2	**Data and Functionality Prioritisation**
Task 3	**Specifications and TOT-CLIC architecting/wireframing (Concept Stage)**
Task 4	**Data Integration and TOT-CLIC (beta) development Initial TOT-CLIC beta version**
Task 5	**Finalised TOT-CLIC Development**
Task 6	**Troubleshooting and Technical Support**

Thanks to Mark Jones and Andrea Latina for their work on the lattice files.

CLIC Study Area

All Datasets have now been acquired and defined:

- Protected Areas:
  - Only the selected areas shown have been included in the tool.
  - The areas identified are those deemed the most relevant at this stage in the project:
    - Natural Habitat of Community interest at Natura 2000 sites (EU).
    - National Natural Reserves. Geneva.
    - Ramsar Sites – (Wetlands)
    - Natural Reserves. France
    - Biotype protection Order – (Protected Habitat).



Note: Listed buildings are covered in the Building data layer.

CLIC Interface

CLIC-TOT Interface:

- Inputs:
  - IP co-ordinates.
  - IP Depth.
  - Gradient.
  - Energy stage.
- Outputs
  - Tunnel section geology
  - Depth of tunnel below any watercourses
  - No. of clashes with boreholes.
  - Shaft length and geology.
  - Surface Constraints.

CLIC Interface

CLIC TOT Interface:

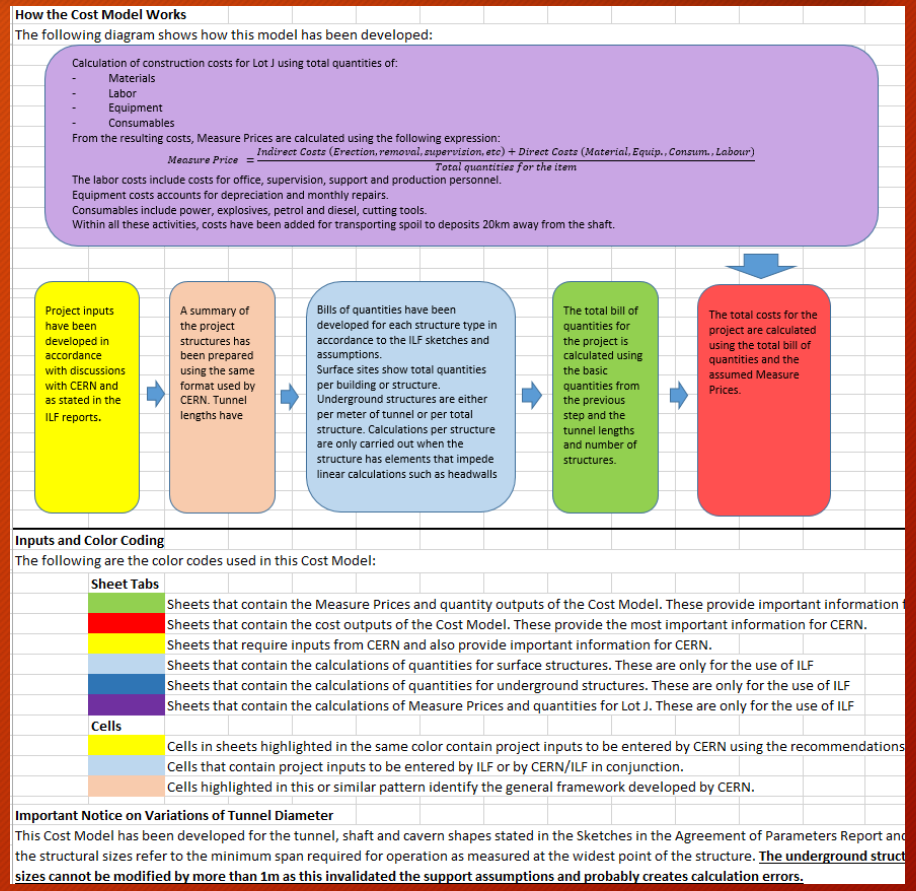
- Comparison Overview
  - Tunnel & shaft geology.
  - Shaft geology and length.
  - Natural features.
  - Shaft locations.
- Related Scenarios
  - Identifies the parent scenario of each newly saved scenario.
  - Attributes to be displayed are still to be identified.

Cost Estimates

FCC Consultants Cost model to be modified for CLIC.

Requirements:

- Cost estimate for the Klystron TBM design
- Cost estimate for the Klystron roadheader design
- Cost Estimate for the New 380 GeV Drive Beam Design
- Comparison to the previous CDR cost estimate for the drive beam.



How the Cost Model Works

The following diagram shows how this model has been developed:

Calculation of construction costs for Lot J using total quantities of:
- Materials
- Labor
- Equipment
- Consumables

From the resulting costs, Measure Prices are calculated using the following expression:

$$Measure\ Price = \frac{Indirect\ Costs\ (Erection, removal, supervision, etc) + Direct\ Costs\ (Material, Equip., Consum., Labour)}{Total\ quantities\ for\ the\ item}$$

The labor costs include costs for office, supervision, support and production personnel.
Equipment costs accounts for depreciation and monthly repairs.
Consumables include power, explosives, petrol and diesel, cutting tools.
Within all these activities, costs have been added for transporting spoil to deposits 20km away from the shaft.

Project inputs have been developed in accordance with discussions with CERN and as stated in the ILF reports.

A summary of the project structures has been prepared using the same format used by CERN. Tunnel lengths have

Bills of quantities have been developed for each structure type in accordance to the ILF sketches and assumptions.
Surface sites show total quantities per building or structure.
Underground structures are either per meter of tunnel or per total structure. Calculations per structure are only carried out when the structure has elements that impede linear calculations such as headwalls

The total bill of quantities for the project is calculated using the basic quantities from the previous step and the tunnel lengths and number of structures.

The total costs for the project are calculated using the total bill of quantities and the assumed Measure Prices.

Inputs and Color Coding

The following are the color codes used in this Cost Model:

Sheet Tabs

- Sheets that contain the Measure Prices and quantity outputs of the Cost Model. These provide important information
- Sheets that contain the cost outputs of the Cost Model. These provide the most important information for CERN.
- Sheets that require inputs from CERN and also provide important information for CERN.
- Sheets that contain the calculations of quantities for surface structures. These are only for the use of ILF
- Sheets that contain the calculations of quantities for underground structures. These are only for the use of ILF
- Sheets that contain the calculations of Measure Prices and quantities for Lot J. These are only for the use of ILF

Cells

- Cells in sheets highlighted in the same color contain project inputs to be entered by CERN using the recommendations
- Cells that contain project inputs to be entered by ILF or by CERN/ILF in conjunction.
- Cells highlighted in this or similar pattern identify the general framework developed by CERN.

Important Notice on Variations of Tunnel Diameter

This Cost Model has been developed for the tunnel, shaft and cavern shapes stated in the Sketches in the Agreement of Parameters Report and the structural sizes refer to the minimum span required for operation as measured at the widest point of the structure. **The underground struct sizes cannot be modified by more than 1m as this invalidated the support assumptions and probably creates calculation errors.**

Cost Estimates

Process:

1. Exhaustive list of all underground, surface and temporary Structures.
2. Dimensional Input tables for all the different structures.
3. Basic Quantities and costs Table for each structure type – options for different tunnelling methods
4. Total quantities and cost for ALL structures.
5. Quantity and cost calculations based on rates used for FCC for each structure type.

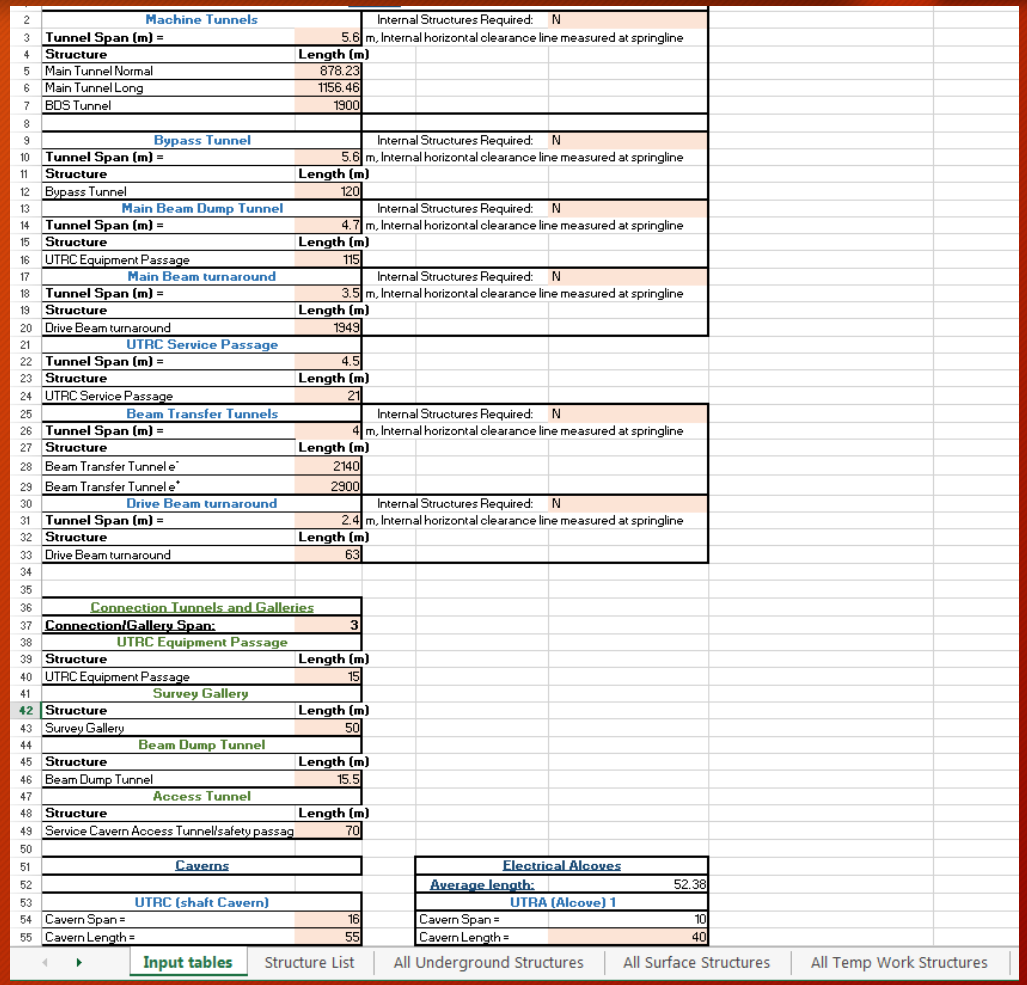
	Surface Structures	Length	Width	Height
2	Access Shaft Electricity Building	20	20	6
3	Booster CV Building	30	30	10
4	Booster CV Building	30	30	10
5	Booster Injector Building	500	5	3
6	Car parking Exp. Area	50	100	
7	Car parking Access Shaft	50	50	
8	Central Area CV Building	40	40	10
9	Central Area Machine Cooling Tower	90	10	17
10	Central Area Station ED	35	30	7
11	Central Area Station EG	35	20	7
12	Compton Ring Building	30	30	7
13	Control Building	50	25	7
14	CR1 Hall + CV	30	40	7
15	CR2 Hall + CV	30	40	7
16	Cryo Cold Building	50	18	12
17	Cryo Warm Building	50	18	12
18	Detector Assembly Hall	100	25	25
19	Drive Beam Cooling Tower	90	10	16
20	Drive Beam Cooling Tower	90	10	16
21	Drive Beam CV Building	25	20	7
22	Drive Beam Injector Building	2560	30	9
23	Drive Beam Station ED	75	42	7
24	Drive Beam Station EG	42	20	7
25	e^- Damping Ring Hall + CV	30	40	7
26	e^+ Damping Ring Hall + CV	30	40	7
27	e^+ Pre Damping Ring Hall + CV	30	40	7
28	Electricity Building	80	20	6
29	Gas Building	40	10	4
30	Gas Storage Tank Platform	32	16	1
31	Injection Hall + CV	30	40	7
32	Linac 1 Target Hall	10	10	7
33	Linac 2 Target Hall	10	10	7
34	Main Beam CV Building	25	20	7
35	Main Beam Cooling Tower	75	10	16
36	Main Beam Injector Buillding	880	7	3
37	Main Beam Station ED	68	35	7
38	Main Beam Station EG	35	15	7
39	Reception Building	40	12	7

Input tables | Structure List | All Underground Structures | **All Surface Structures** | All Temp Work Structures | Basic C

Cost Estimates

Process:

1. Exhaustive list of all underground, surface and temporary Structures.
2. Dimensional Input tables for all the different structures.
3. Basic Quantities and costs Table for each structure type – options for different tunnelling methods
4. Total quantities and cost for ALL structures.
5. Quantity and cost calculations based on rates used for FCC for each structure type.



Machine Tunnels		Internal Structures Required:	N
Tunnel Span (m) =	5.6	m, Internal horizontal clearance line measured at springline	
Structure	Length (m)		
Main Tunnel Normal	878.23		
Main Tunnel Long	1156.46		
BDS Tunnel	1900		
Bypass Tunnel		Internal Structures Required:	N
Tunnel Span (m) =	5.6	m, Internal horizontal clearance line measured at springline	
Structure	Length (m)		
Bypass Tunnel	120		
Main Beam Dump Tunnel		Internal Structures Required:	N
Tunnel Span (m) =	4.7	m, Internal horizontal clearance line measured at springline	
Structure	Length (m)		
UTRC Equipment Passage	115		
Main Beam turnaround		Internal Structures Required:	N
Tunnel Span (m) =	3.5	m, Internal horizontal clearance line measured at springline	
Structure	Length (m)		
Drive Beam turnaround	1949		
UTRC Service Passage			
Tunnel Span (m) =	4.5		
Structure	Length (m)		
UTRC Service Passage	21		
Beam Transfer Tunnels		Internal Structures Required:	N
Tunnel Span (m) =	4	m, Internal horizontal clearance line measured at springline	
Structure	Length (m)		
Beam Transfer Tunnel e⁻	2140		
Beam Transfer Tunnel e⁺	2900		
Drive Beam turnaround		Internal Structures Required:	N
Tunnel Span (m) =	2.4	m, Internal horizontal clearance line measured at springline	
Structure	Length (m)		
Drive Beam turnaround	63		
Connection Tunnels and Galleries			
Connection/Gallery Span:	3		
UTRC Equipment Passage			
Structure	Length (m)		
UTRC Equipment Passage	15		
Survey Gallery			
Structure	Length (m)		
Survey Gallery	50		
Beam Dump Tunnel			
Structure	Length (m)		
Beam Dump Tunnel	15.5		
Access Tunnel			
Structure	Length (m)		
Service Cavern Access Tunnel/safety passag	70		
Caverns		Electrical Alcoves	
		Average length:	52.38
UTRC (shaft Cavern)		UTRA (Alcove) 1	
Cavern Span =	16	Cavern Span =	10
Cavern Length =	55	Cavern Length =	40

Input tables | Structure List | All Underground Structures | All Surface Structures | All Temp Work Structures

Cost Estimates

Process:

1. Exhaustive list of all underground, surface and temporary Structures.
2. Dimensional Input tables for all the different structures.
3. Basic Quantities and costs Table for each structure type – options for different tunnelling methods
4. Total quantities and cost for ALL structures.
5. Quantity and cost calculations based on rates used for FCC for each structure type.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
12				(EUR/m³)	(EUR/m³)	(EUR/m³)	(EUR/m³)	(EUR/m³)	(EUR/kg)	(EUR/m)	(EUR/m²)	(EUR/kg)	(EUR/m³)	(EUR/kg)	(EUR/m³)	(EUR/m²)	(EUR/kg)	(EUR/m³)	(EUR/m³)	(EUR/
13	Measure Price (EUR)			287.39	204.05	264.57	756.18	300.07	2.11	31.70	540.50	2.11	581.13	2.11	183.85	226.11	2.11	31.70	226.11	2
14	Factor for Material Cost Variability:				1.00															
15				G. Treatment	TBM Excav.	H Mined Excav.	V. Mined Excav.	Shotcrete	Shotcrete Re.	Rookbolts	D-Wall C.	D-Wall R.	Pre-Cast C.	Pre-Cast R.	Annulus Grout	Cast Insitu C.	Cast Insitu R.	Waterproofing	Invert Concrete	Invert R
16				(EUR/m³)	(EUR/m³)	(EUR/m³)	(EUR/m³)	(EUR/m³)	(EUR/kg)	(EUR/m)	(EUR/m²)	(EUR/kg)	(EUR/m³)	(EUR/kg)	(EUR/m³)	(EUR/m²)	(EUR/kg)	(EUR/m²)	(EUR/m³)	(EUR/
17	Factored Measure Price (EUR)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
18	**Underground Quantities Per Meter Run of Tunnel**																			
19			Wastage Factor =	1.20	1.10	1.10	1.10	1.25	1.05	1.05	1.10	1.05	1.10	1.05	1.20	1.10	1.05	1.10	1.10	
20	Type No.	Structure		G. Treatment	TBM Excav.	H Mined Excav.	V. Mined Excav.	Shotcrete	Shotcrete Re.	Rookbolts	D-Wall C.	Pile R.	Pre-Cast C.	Pre-Cast R.	Annulus Grout	Cast Insitu C.	Cast Insitu R.	Waterproofing	Invert Concrete	Invert R
21				m³/m	m³/m	m³/m	m³/m	m³/m	kg/m	ml/m	m³/m	kg/m	m³/m	kg/m	m³/m	m³/m	kg/m	m²/m	m³/m	kg/m
22	1	Machine Tunnel – TBM Option 1		0.26	38.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.28	719.16	3.68	0.00	0.00	0.00	4.66	267
23	2	Machine Tunnel – TBM Option 2		0.28	44.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.85	784.48	3.99	1.69	1.61	7.87	6.65	380
24	3	Machine Tunnel – Mined Tunnel G. Rock		0.26	0.00	35.58	0.00	3.72	62.44	11.38	0.00	0.00	0.00	0.00	0.00	3.59	102.68	14.58	3.43	196
25	4	Machine Tunnel – Mined Tunnel Poor G.		2.01	0.00	39.01	0.00	7.67	322.07	23.63	0.00	0.00	0.00	0.00	0.00	4.34	310.60	14.74	3.77	216
26	5	Bypass Tunnel – TBM Option 1		0.26	38.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.28	719.16	3.68	0.00	0.00	0.00	4.66	267
27	6	Bypass Tunnel – TBM Option 2		0.28	44.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.85	784.48	3.99	1.69	1.61	7.87	6.65	380
28	7	Bypass Tunnel – Mined Tunnel G. Rock		0.27	0.00	40.19	0.00	3.95	82.99	11.38	0.00	0.00	0.00	0.00	0.00	3.75	107.33	15.25	4.84	277
29	8	Bypass Tunnel – Mined Tunnel Poor G.		2.10	0.00	43.82	0.00	8.14	410.24	23.63	0.00	0.00	0.00	0.00	0.00	4.53	324.50	15.41	5.22	298
30	9	Beam Transfer Tunnel – TBM Option 1		0.20	21.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.60	527.26	2.77	0.00	0.00	0.00	0.41	2
31	10	Beam Transfer Tunnel – TBM Option 2		0.22	27.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.17	592.57	3.08	1.35	1.29	5.85	1.59	90
32	11	Beam Transfer Tunnel – Mined Tunnel G. Rock		0.27	0.00	40.19	0.00	3.95	82.99	11.38	0.00	0.00	0.00	0.00	0.00	3.75	107.33	15.25	4.84	277
33	12	Beam Transfer Tunnel – Mined Tunnel Poor G.		2.10	0.00	43.82	0.00	8.14	410.24	23.63	0.00	0.00	0.00	0.00	0.00	4.53	324.50	15.41	5.22	298
34	13	M. Dump Tunnel – TBM Option 1		0.23	28.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.34	611.22	3.17	0.00	0.00	0.00	1.14	69
35	14	M. Dump Tunnel – TBM Option 2		0.25	34.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.91	676.53	3.48	1.56	1.49	6.73	2.53	144
36	15	M. Dump Tunnel – Mined Tunnel G. Rock		0.27	0.00	40.19	0.00	3.95	82.99	11.38	0.00	0.00	0.00	0.00	0.00	3.75	107.33	15.25	4.84	277
37	16	M. Dump Tunnel – Mined Tunnel Poor G.		2.10	0.00	43.82	0.00	8.14	410.24	23.63	0.00	0.00	0.00	0.00	0.00	4.53	324.50	15.41	5.22	298
38	17	Drive Beam Turnaround – Good Rock		0.14	0.00	8.89	0.00	1.81	30.47	7.58	0.00	0.00	0.00	0.00	0.00	1.38	39.40	7.04	0.86	65
39	18	Drive Beam Turnaround – Poor Ground		1.25	0.00	10.65	0.00	3.22	135.22	7.58	0.00	0.00	0.00	0.00	0.00	1.75	125.33	7.21	1.02	77
40	19	Main Beam Turnaround – Good Rock		0.18	0.00	16.08	0.00	2.46	41.36	7.58	0.00	0.00	0.00	0.00	0.00	1.73	49.58	8.89	3.10	236
41	20	Main Beam Turnaround – Poor Ground		1.50	0.00	18.40	0.00	4.30	180.57	7.58	0.00	0.00	0.00	0.00	0.00	2.19	156.93	9.06	3.35	255
42	21	Access Shafts – Good Rock		9.70	0.00	0.00	171.24	3.25	0.00	0.00	71.15	0.00	0.00	0.00	0.00	29.52	4226.84	37.67	0.00	0
43	22	Access Shaft – Poor Ground		1.30	0.00	0.00	95.25	10.06	169.06	73.50	0.00	0.00	0.00	0.00	0.00	13.27	760.01	34.56	0.00	0
44	23	Machine shaft – Good Rock		16.08	0.00	0.00	465.56	4.18	0.00	0.00	129.26	0.00	0.00	0.00	0.00	62.87	9001.66	69.46	0.00	0
45	24	Machine Shaft – Poor Ground		2.34	0.00	0.00	335.29	19.09	320.80	88.20	0.00	0.00	0.00	0.00	0.00	32.31	1850.56	66.35	0.00	0
46	25	Survey Boring Shaft – Good Rock		4.07	0.00	0.00	7.78	0.00	0.00	0.00	0.00	0.00	2.70	128.65	0.56	2.07	296.88	7.95	0.00	0
47	26	Survey Boring Shaft – Poor Ground		0.62	0.00	0.00	4.98	1.33	22.27	49.00	0.00	0.00	0.00	0.00	0.00	1.31	75.21	7.26	0.00	0
48	27	Connection Tunnels & Galleries G. Rock MT		0.16	0.00	12.55	0.00	2.17	36.41	7.58	0.00	0.00	0.00	0.00	0.00	1.57	44.86	8.04	1.95	148
49	28	Connection Tunnels & Galleries P. Ground MT		1.39	0.00	14.62	0.00	3.81	159.96	7.58	0.00	0.00	0.00	0.00	0.00	1.99	142.26	8.21	2.16	164
50	29	Drive Beam Turnaround Enlargement – Good Rock																		
51	30	Drive Beam Turnaround Enlargement – Poor Ground																		
52	**QUANTITIES PER STRUCTURE**																			
53	Type No.	Structure		G. Treatment	TBM Excav.	H Mined Excav.	V. Mined Excav.	Shotcrete	Shotcrete Re.	Rookbolts	D-Wall C.	Pile R.	Pre-Cast C.	Pre-Cast R.	Annulus Grout	Cast Insitu C.	Cast Insitu R.	Waterproofing	Invert Concrete	Invert R
54				m³/m	m³/m	m³/m	m³/m	m³/m	kg/m	ml/m	m³/m	kg/m	m³/m	kg/m	m³/m	m³/m	kg/m	m²/m	m³/m	kg/m
55	101	UTRC Shaft Cavern – Good Rock		127.71	0.00	19229.87	0.00	1224.74	20575.61	2706.90	0.00	0.00	0.00	0.00	0.00	2280.96	235972.92	3287.51	2336.96	66927
56	102	UTRC Shaft Cavern – Poor Ground		863.30	0.00	20521.91	0.00	1768.79	74289.01	6684.30	0.00	0.00	0.00	0.00	0.00	2492.66	417960.86	3351.49	2529.37	72433
57	103	UTRC Shielding Door Cavern – Good Rock																		
58	104	UTRC Shielding Door Cavern – Poor Ground																		

Basic Quantities and Costs | Total Quantities U | Total Quantities S | Total Quantities T | Total Cost U | Total Cost S | Total Cost T | Cc ...

Cost Estimates

Process:

1. Exhaustive list of all underground, surface and temporary Structures.
2. Dimensional Input tables for all the different structures.
3. Basic Quantities and costs Table for each structure type – options for different tunnelling methods
4. Total quantities and cost for ALL structures.
5. Quantity and cost calculations based on rates used for FCC for each structure type.

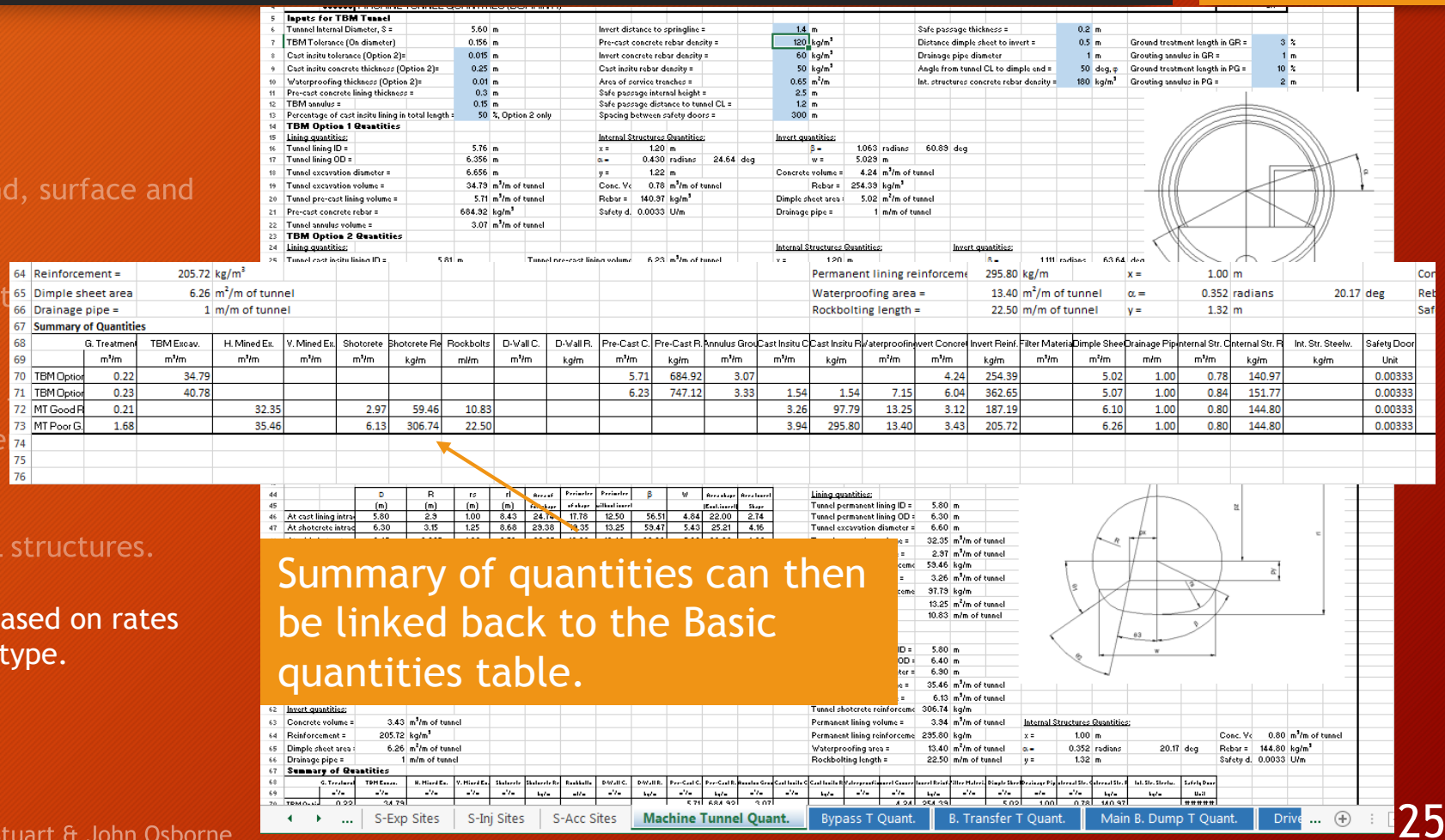
Type	Location	Function	Location	Structure Length	Ground Treatment	TBM Excavation	Horizontal Mined Excavation	Vertical Mined Excavation	Shotcrete	Shotcrete Reinf.	Rockbolts	Concrete for D-Walls	Reinf. for D-Walls	Pre-Cast Concrete	Pre-Cast Concrete Reinf.	Annulus Grout
	20	Main Tunnel	09													
1		Machine Tunnel - TBM Option 1														
2		Machine Tunnel - TBM Option 2														
3		Machine Tunnel - Mined Tunnel G. Rock														
4		Machine Tunnel - Mined Tunnel Poor G.														
	End 3TeV	Main Tunnel	End 3TeV													
1		Machine Tunnel - TBM Option 1														
2		Machine Tunnel - TBM Option 2														
3		Machine Tunnel - Mined Tunnel G. Rock														
4		Machine Tunnel - Mined Tunnel Poor G.														
		Bypass Tunnel														
	BDS1	Bypass Tunnel	BDS 1													
5		Bypass Tunnel - TBM Option 1														
6		Bypass Tunnel - TBM Option 2														
7		Bypass Tunnel - Mined Tunnel G. Rock														
8		Bypass Tunnel - Mined Tunnel Poor G.														
	BDS2	Bypass Tunnel	BDS2													
5		Bypass Tunnel - TBM Option 1														
6		Bypass Tunnel - TBM Option 2														
7		Bypass Tunnel - Mined Tunnel G. Rock														
8		Bypass Tunnel - Mined Tunnel Poor G.														
		Beam Transfer Line Tunnels														
	BDS1	Beam Transfer Tunnels	BDS 1													
9		Beam Transfer Tunnel - TBM Option 1														
10		Beam Transfer Tunnel - TBM Option 2														
11		Beam Transfer Tunnel - Mined Tunnel G. Rock														
12		Beam Transfer Tunnel - Mined Tunnel Poor G.														
	BDS2	Beam Transfer Tunnels	BDS 2													
9		Beam Transfer Tunnel - TBM Option 1														
10		Beam Transfer Tunnel - TBM Option 2														
11		Beam Transfer Tunnel - Mined Tunnel G. Rock														
12		Beam Transfer Tunnel - Mined Tunnel Poor G.														
		Main Beam Dump Tunnel														
	BDS 1	Main Beam Dump Tunnel	BDS 1													
13		M. Dump Tunnel - TBM Option 1														
14		M. Dump Tunnel - TBM Option 2														
15		M. Dump Tunnel - Mined Tunnel G. Rock														
16		M. Dump Tunnel - Mined Tunnel Poor G.														
	BDS 2	Main Beam Dump Tunnel	BDS 2													

Basic Quantities and Costs | Total Quantities U | Total Quantities S | Total Quantities T | Total Cost U | Total Cost S | Total Cost T | Cc ...

Cost Estimates

Process:

1. Exhaustive list of all underground, surface and temporary Structures.
2. Dimensional Input tables for all t structures.
3. Basic Quantities and costs Table structure type – options for diffe methods
4. Total quantities and cost for ALL structures.
5. Quantity and cost calculations based on rates used for FCC for each structure type.



Cost Breakdown from CDR

"The difference in value between the two scenarios is the price to pay for the higher luminosity of 500 GeV in scenario A: the higher beam current requires additional RF power to be installed in the injectors and larger-aperture accelerating structures operating at lower gradient, thus calling for an additional fifth sector in each of the main linacs"

Table showing the cost breakdown of the 500 GeV Scenario A and B

		Value A [MCHF]	Value B [MCHF]
Civil engineering and services	Civil engineering	1432	1382
	Electricity	326	282
	Survey and alignment	31	31
	Fluids	494	445
	Transport/installation	100	90
	Safety	20	20
	Total	2403	2250

https://edms.cern.ch/ui/file/1235960/3/cliccdr_CLICProgramme_onlineversion.pdf

Summary

Future Study - TBM Tunnel.

- Compatibility with a smaller single tunnel upgrade requires further study.
- Failure rate of klystron modules is high – what are the access requirements for maintenance and is this possible with 1.5m shielding wall?
- First Cost Estimates and Comparisons to be done using the Costing Worksheet.
- Radiation study for the shielding wall to be initiated.
- First indication is that a TBM tunnel is cheaper than an ILC shaped mined tunnel.

CLIC TOT

- Tool is currently in testing, any feedback is welcome.

Civil Drawings

- Cross Sections to be amended to account for any changes in Transport and CV systems.
- Produce 3D schematics of the Klystron Machine.
- Integration of known services into the cross-sections from each discipline.
- Continually update the drawings as and when new information is acquired.

- **Next Meeting is on the 01st of December.**
- **LCW Strasbourg: 23rd to the 27th October – Breakdown of costs by discipline required.**
- **CLIC Workshop at CERN 22nd to the 26th January – Update from each team required.**

Thank You For Your Attention

Thank you to all contributors

(John Osborne, Raul Ortega, Youri Robert etc…)