

COOLING & VENTILATION INFRASTRUCTURE

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CLIC CEIS Working Group Meeting 31/08/2018

Outline

1 – CV PiP Chapter

2 – Energetic Summary

3 – Future work

4 – Conclusions

PiP Chapter

- Piped Utilities
- Ventilation Infrastructure

PiP Chapter

➢Piped Utilities

- Industrial / Demineralized Water : Refrigeration
- Chilled Water : Air Handling Units
- Drinking Water : Make-Up Water
- Industrial Water : Fire-Fighting Systems
- Waste Water
- Compressed Air

PiP Chapter

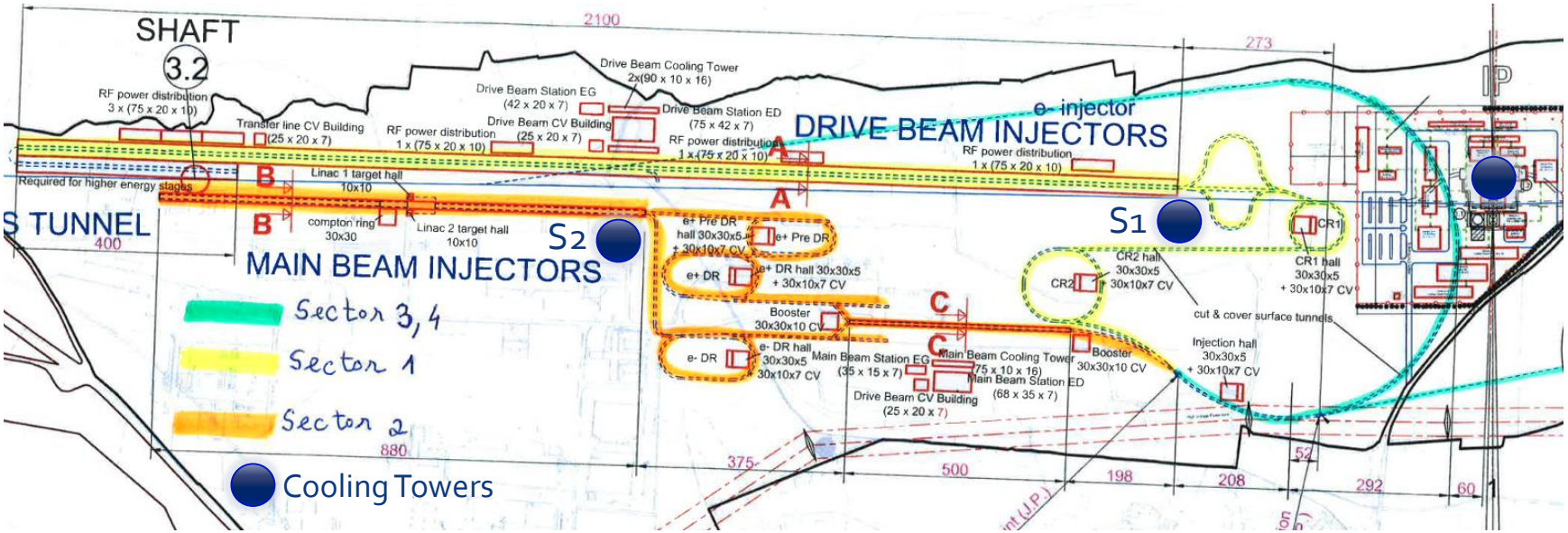
- Piped Utilities
  - Water Cooling Sectors

1 – Drive Beam Injector Complex

2 – Main Tunnel

3 – Experimental Complex

4 – Main Beam Injector Complex

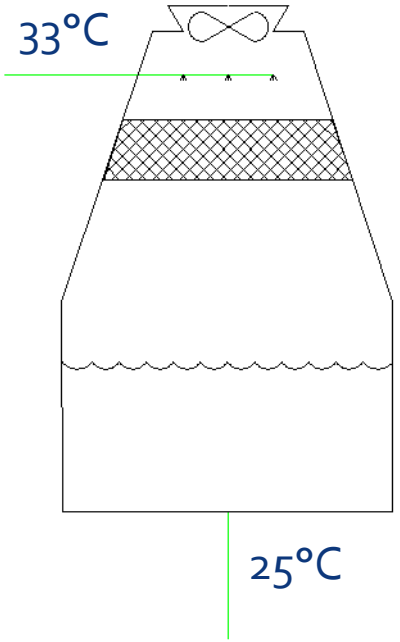


PiP Chapter

➢Piped Utilities

- Primary Cooling Circuits

  - Cooled by cooling towers
  - Industrial water
  - To refrigerate:
    - Secondary demineralized water circuits
    - Secondary industrial water circuits (exceptions)
    - Chillers
    - DX units

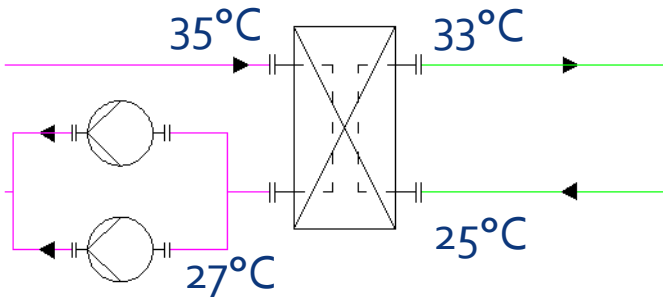


PiP Chapter

➢Piped Utilities

- Secondary Cooling Circuits

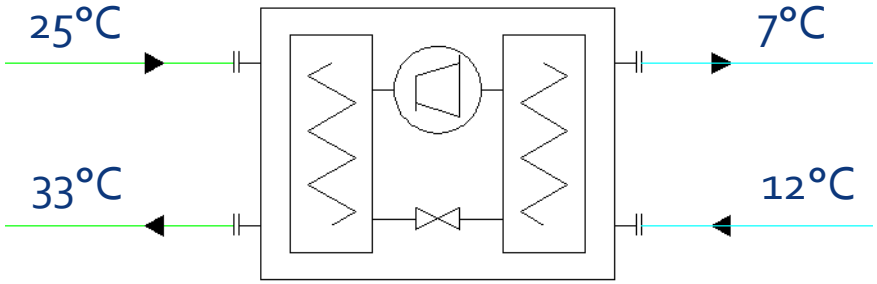
  - Cooled by a primary circuit
  - Generally demineralized water
  - To refrigerate:
    - Mainly equipment related to the accelerator



PiP Chapter

➢Piped Utilities

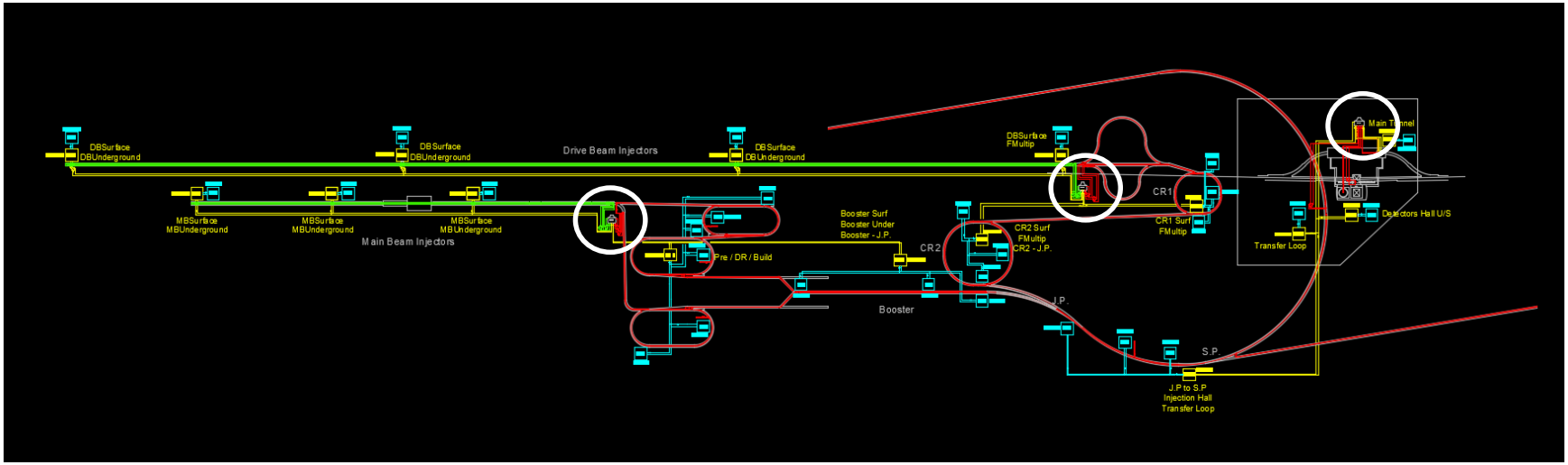
- Chilled Water Circuits
  - Cooled by chillers
  - Industrial water
  - To refrigerate:
    - AHUs



PiP Chapter

➢Piped Utilities

- Piping Layout at Surface/ Shallow Underground (not included in the PiP)



PiP Chapter

➢ Piped Utilities

Primary Circuits

Sector	Structure: Name	Two Beam Machine: Cooling Power [kW]	Two Beam Machine: Flow Rate [m³/h]	Two Beam Machine: Cooling Towers	Klystron Machine: Cooling Power [kW]	Klystron Machine: Flow Rate [m³/h]	Klystron Machine: Cooling Towers
1	Drive Beam Injector U	5356	577	6x10MW			
	Drive Beam Injector S	14191	1529				
	Frequency Multiplication Circuit a)	3238	349				
	Frequency Multiplication Circuit b), CR1 S, CR2 S and Transfer Line - CR2 to J.P.	16811	1811		na	na	na
	Chillers Refrigeration - Drive Beam Injector S/U, Frequency Multiplication Circuit 1	8106	873				
	Chillers Refrigeration - CR1 S, CR2 S, Frequency Multiplication Circuit 2, 3, 4 and Transfer Line - CR2 to J.P.	1811	195				
2/3	Accelerator - Klystron	na	na	8x10MW	24778	2669	8x14MW
	Accelerator - LINAC	18563	2000		27128	2922	
	Main Tunnel (other equipment)	35365	3809		24149	2601	
	Injection Hall and Transfer Lines - e^+/e^-, Loop, J.P to S.P (P&ID Circuit B)	5931	639		5931	639	
	Detectors S	900	97		900	97	
	Detectors U	2043	220		2043	220	
	Chillers Refrigeration - [illegible]	5311	572		3757	405	
	Chillers Refrigeration - [illegible] Hall S/U, Injection Hall, Transfer Lines - Loop and J.P. to S.P. (P&ID Circuit A)	1317	142		4516	486	
4	Main Beam Injector U	3886	419	5x10MW	3886	419	5x10MW
	Main Beam Injector S	5126	552		5126	552	
	Booster S/U, Damping Ring e^- S/U, and Transfer Line - Booster to J.P.	11205	1207		11205	1207	
	Pre Damping Ring S/U, Damping Ring e^+ S/U	8307	895		8307	895	
	Chillers Refrigeration - Main Beam Injector S/U	2136	230		2136	230	
	Chillers Refrigeration - Pre Damping Ring S/U, Damping Rings e^+, e^- S/U, Booster S/U and Transfer Line - Booster to J.P.	4719	508		4719	508	
	Total Cooling [MW]	154			129		

Not updated tables

Secondary Circuits, Demineralized Water

Sector	Structure: Name	Two Beam Machine: Cooling Power [kW]	Two Beam Machine: Flow Rate [m³/h]	Klystron Machine: Cooling Power [kW]	Klystron Machine: Flow Rate [m³/h]
1	Drive Beam Injector U	5356	577	na	na
	Drive Beam Injector S	14191	1529	na	na
	Frequency Multiplication Circuit a)	3238	349	na	na
	Frequency Multiplication Circuit b), CR1 S, CR2 S and Transfer Line - CR2 to J.P.	16811	1811	na	na
2/3	Accelerator - Klystron	na	na	24778	2669
	Accelerator - LINAC	18563	2000	27128	2922
	Main Tunnel (other equipment)	35365	3809	24149	2601
	Injection Hall and Transfer Lines - e^+/e^-, Loop, J.P to S.P	5931	639	5931	639
	Detectors S	900	97	900	97
	Detectors U	2043	220	2043	220
4	Main Beam Injector U	3886	419	3886	419
	Main Beam Injector S	5126	552	5126	552
	Pre Damping Ring S/U, Damping Ring e^+ S/U	8307	895	8307	895
	Booster S/U, Damping Ring e^- S/U, and Transfer Line - Booster to J.P.	11205	1207	11205	1207
	Total Cooling [MW]	131		113	

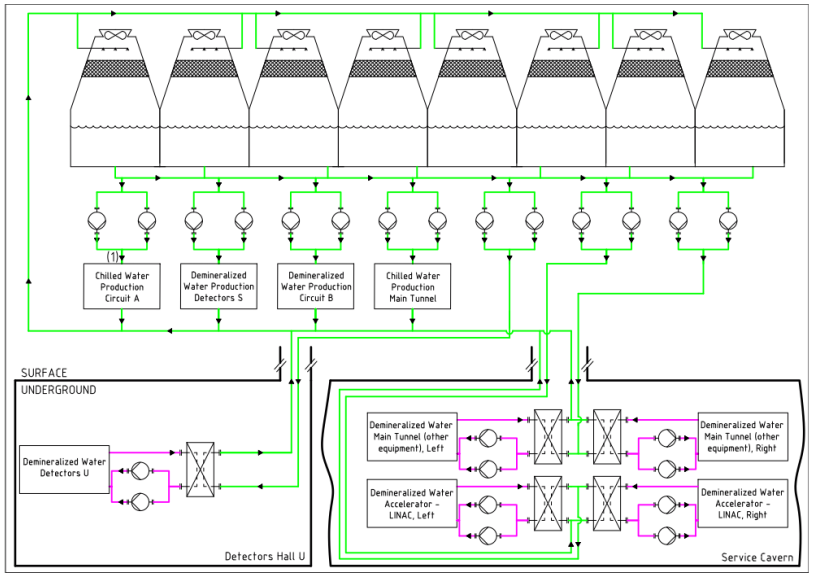
Chilled Water Circuits

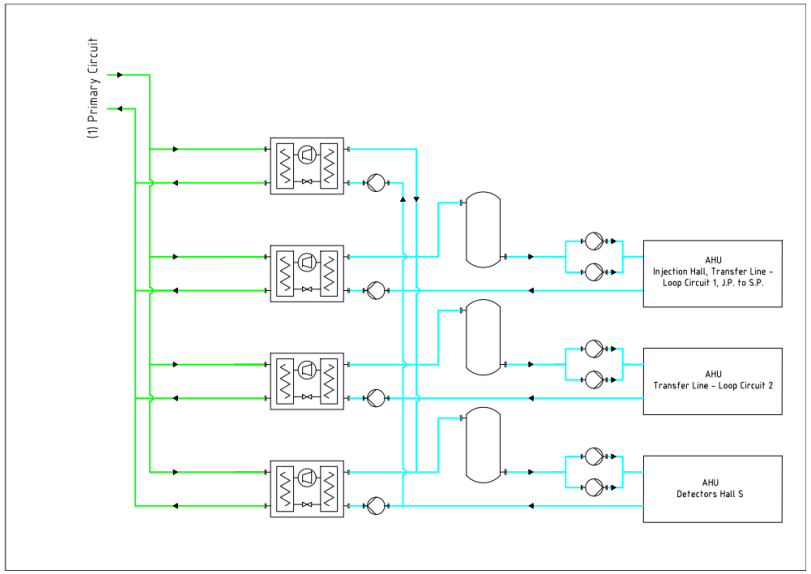
Sector	Structure: Name	Two Beam Machine: Cooling Power [kW]	Two Beam Machine: Flow Rate [m³/h]	Klystron Machine: Cooling Power [kW]	Klystron Machine: Flow Rate [m³/h]
1	Drive Beam Circuit 1	1952	336		
	Drive Beam Circuit 2	1413	243		
	Drive Beam Circuit 3	1413	243		
	Drive Beam Injector S and Frequency Multiplication Circuit 1	1458	251	na	na
	CR2 S, Frequency Multiplication Circuit 4 and Transfer Line - CR2 to J.P.	824	142		
	CR1 S and Frequency Multiplication Circuits 2,3	569	98		
2/3	Injection Hall, Transfer Line - Loop Circuit 1, J.P. to S.P.	555	96	555	345
	Transfer Line - Loop Circuit 2	115	20	115	71
	Detectors Hall U	118	20	118	74
	Detectors Hall S	225	39	225	140
	Main Tunnel	4085	704	5351	922
4	Main Beam S/U Circuit 1	820	141	820	510
	Main Beam S/U Circuit 2	412	71	412	256
	Main Beam S/U Circuit 3	412	71	412	256
	Booster S/U and Transfer Line - Booster to J.P.	944	163	944	587
	Damping Rings S/U and Pre Damping Rings S/U	2686	463	2686	1670
	Total Cooling [MW]	18		12	

- ❖ N+1 Redundancy for Cooling Towers & Pumps

PiP Chapter

➢Piped Utilities





- ❖ Simplified P&IDs for sector 2 and 3
- ❖ Ventilation P&ID will be present in the PiP

P&IDs are not updated

PiP Chapter

➢Ventilation Infrastructure

- Design Indoor Conditions
  - Deep Underground: 28°C, Dew Point < 12°C
  - Shallow Underground: 22°C, Dew Point < 12°C
  - Surface Buildings: 18°C during winter, 25°C during summer
- Design Outdoor Conditions
  - Summer: 32°C, 40% RH
  - Winter: -12°C, 90% RH

PiP Chapter

➢Ventilation Infrastructure

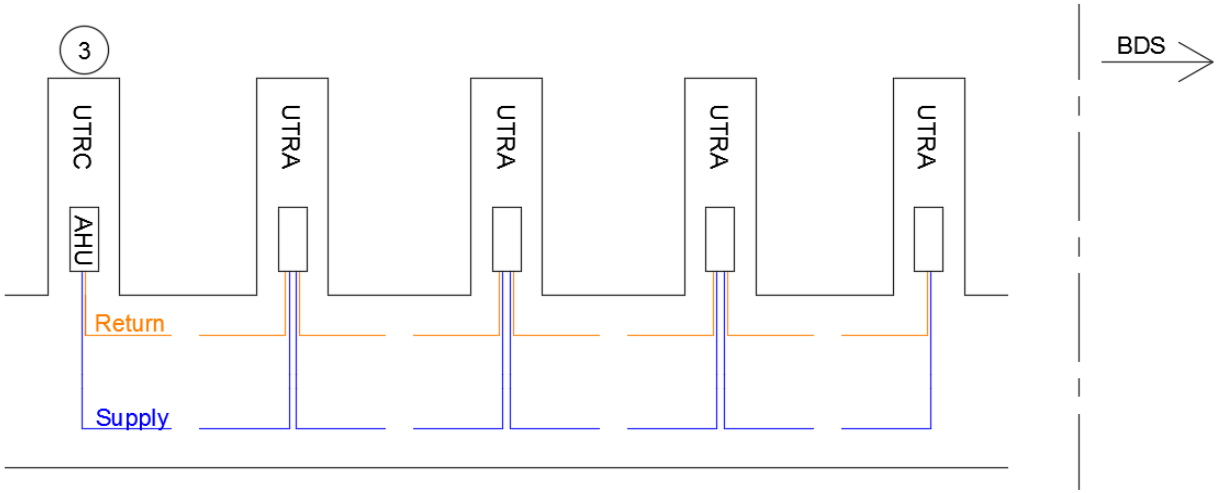
- Operational Modes

Mode	Conditions
Run	No access, machines running, maximum air recycling
Purge	Before access where it is necessary, accelerator stopped, only fresh air
Shutdown	Open access, accelerator stopped, fresh air supply for people

PiP Chapter

➢Ventilation Infrastructure

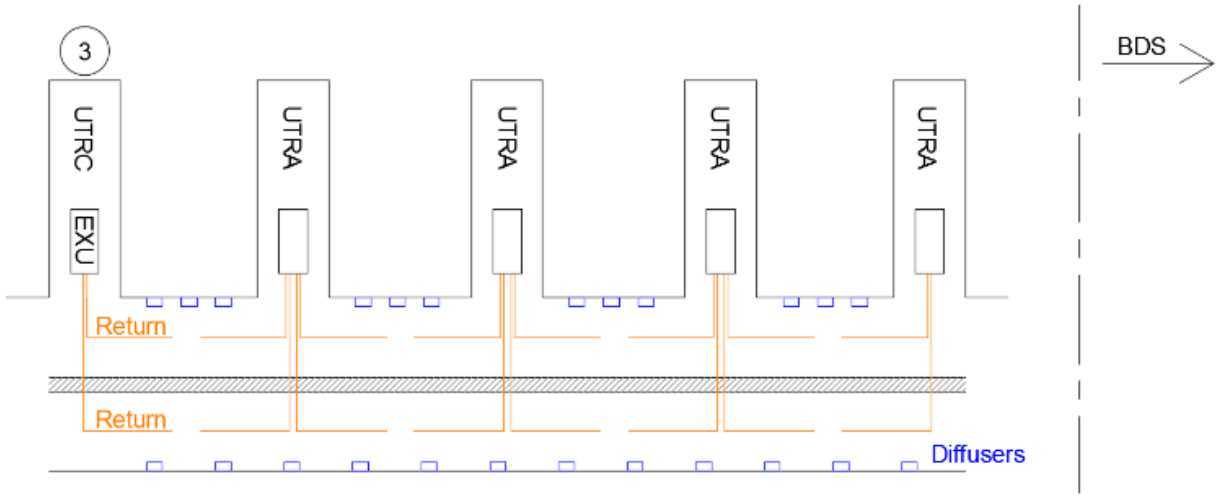
- Accelerator Gallery, Two Beam Machine



PiP Chapter

➢Ventilation Infrastructure

- Accelerator Gallery, Klystron Machine



PiP Chapter

➢Ventilation Infrastructure

- Other Areas

- BDS, Caverns, Dumps and Turnarounds - Detectors Hall - Injectors	• AHUs & EXUs at the surface when possible / underground otherwise • Air transport by ducts
- Injectors Complex - Transfer Lines - Damping and Combiner	• AHUs & EXUs at the surface • Push & Pull ventilation
- Surface Buildings	• AHUs & EXUs at the surface • Air transport by ducts

PiP Chapter

➢Ventilation Infrastructure

Ventilation Infrastructure

Structure		Two Beam Machine			Klystron Machine		
		Air-Handling Units			Air-Handling Units		
Name	N°	N°	Cooling Power	Flow Rate	N°	Cooling Power	Flow Rate
	-	*na*	kW	m³/h	*na*	kW	m³/h
Accelerator Gallery - LINAC	1	6	185	100532	8	193	104541
		4	93	50266			
Accelerator Gallery - Klystron	1	*na*	*na*	*na*	16	84	45775

Ventilation Infrastructure

Sector	Structure		Two Beam Machine		Klystron Machine	
			Air-Handling Units		Air-Handling Units	
	Name	N°	N°	Cooling Power	N°	Cooling Power
		-	*na*	kW	*na*	kW
1	Drive Beam Injector S	1	40	126	*na*	*na*
	CR1 S and CR2 S	2	4	107		
2/3	Detectors Hall S	1	2	113	2	113
	Injection Hall	1	2	108	2	108
4	Main Beam Injector S	1	9	99	9	99
	Booster S	1	6	98	6	98
	Damping Rings e⁺/e⁻ S and Pre Damping Ring S	3	2	106	2	106

Ventilation Infrastructure

Sector	Structure		Two Beam Machine				Klystron Machine			
			Air-Handling Units		Extraction Units		Air-Handling Units		Extraction Units	
	Name	N°	N°	Cooling Power	Flow Rate	N°	Flow Rate	N°	Cooling Power	Flow Rate	N°	Flow Rate
		-	*na*	kW	m³/h	*na*	m³/h	*na*	kW	m³/h	*na*	m³/h
1	Drive Beam Injector U	1	1	691	90730	3	90730	*na*	*na*	*na*	*na*	*na*
			2	152	90730							
	Frequency Multiplication U	1	1	198	96716	1	96716	*na*	*na*	*na*	*na*	*na*
			1	81	48358	1	48358	*na*	*na*	*na*	*na*	*na*
			1	61	36269	1	36269	*na*	*na*	*na*	*na*	*na*
			1	245	60448	1	60448	*na*	*na*	*na*	*na*	*na*
	Transfer Line - CR2 to J.P.	1	1	152	67164	1	67164	*na*	*na*	*na*	*na*	*na*
2/3	Transfer Line - J.P. to S.P.	1	1	225	134328	1	134328	1	225	134328	1	134328
	Transfer Line - Loop	1	2	115	68657	2	68657	2	115	68657	2	68657
	Transfer Line - e^+	1	1	0	16433	0	0	1	0	16433	0	0
	Transfer Line - e^-	1	1	0	24905	0	0	1	0	24905	0	0
	Detectors Hall U	1	1	118	64179	*na*	*na*	1	118	64179	*na*	*na*
	Main Beam Dumps	2	1	31	16561	*na*	*na*	1	31	16561	*na*	*na*
	Drive Beam Dumps	10	1	6	2985	*na*	*na*	*na*	*na*	*na*	*na*	*na*
	Drive Beam Turnaround	8	1	11	597	*na*	*na*	*na*	*na*	*na*	*na*	*na*
	UTRA	8	1	104	56693	*na*	*na*	1	104	56693	*na*	*na*
	UTRC	2	1	104	56693	*na*	*na*	1	104	56693	*na*	*na*
	Caverns 1.3 and 1.4	2	1	104	56693	*na*	*na*	1	104	56693	*na*	*na*
	Survey Cavern 2.1 and 3.1	2	1	0	3000	*na*	*na*	1	0	3000	*na*	*na*
	Additional Caverns 2.2 and 3.2	2	1	165	89552	*na*	*na*	1	165	89552	*na*	*na*
	Service Cavern	2	2	104	56693	*na*	*na*	2	104	56693	*na*	*na*
	BDS	1	4	121	65923	*na*	*na*	4	121	65923	*na*	*na*
	Main Beam Turnaround e^+/e^- and Tunnel BC2 e^+/e^-	2	1	39	20896	*na*	*na*	1	39	20896	*na*	*na*
	BC2 Caverns	2	1	22	11940	*na*	*na*	1	22	11940	*na*	*na*
	Lift Pressurized Area	1	1	0	12000	*na*	*na*	1	0	12000	*na*	*na*
4	Main Beam Injector U	1	1	524	68780	4	68780	1	524	68780	4	68780
			2	115	68780			2	115	68780		
	Booster U	1	2	101	60062	3	60062	2	101	60062	3	60062
	Transfer Line - Booster to J.P.	1	1	155	67164	1	67164	1	155	67164	1	67164
	Pre Damping Ring U	1	1	833	159185	1	159185	1	833	159185	1	159185
	Damping Rings e^+/e^- U	2	1	607	203951	1	203951	1	607	203951	1	203951

Tables are not updated

- Redundancy is considered in the tables within the PiP and is generally required for AHUs & EXUs
- In the UTRAs/UTRCs there might not be redundant AHUs due to space constraints. Hence, in the table, they have not been considered

PiP Chapter

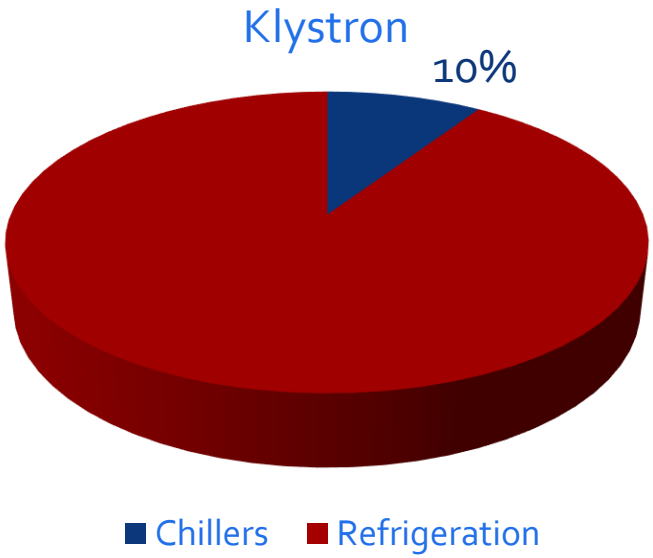
➢Ventilation Infrastructure

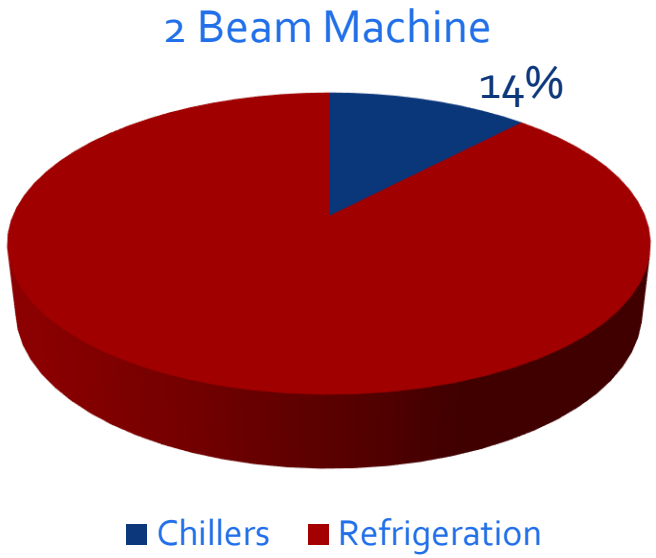
- Safety

  - Smoke extraction where required
  - The ventilation system can be operated by the fire brigade
  - Smoke sensors will be placed before the supply fans in every AHU
  - Air monitoring equipment will be placed at the exhaust for radiation protection
  - The lift and stairs are pressurized
  - A pressure cascade will probably be implemented to avoid the migration of activated air from areas of high levels to areas with low levels of activation

CLiC CV

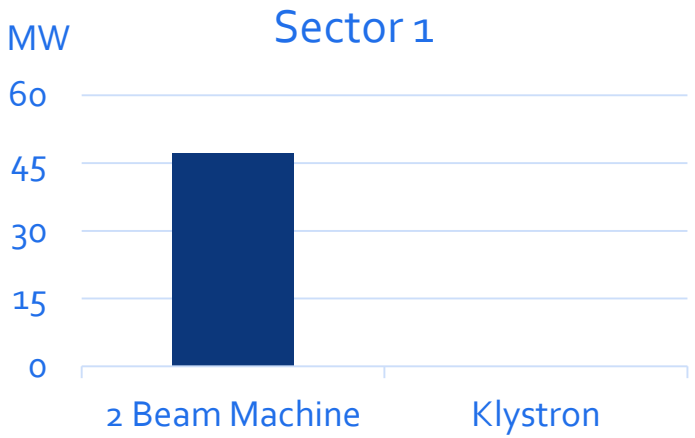
- Cooling Power

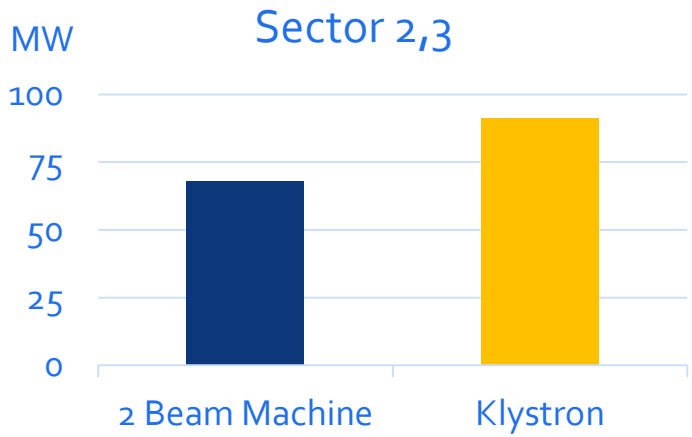


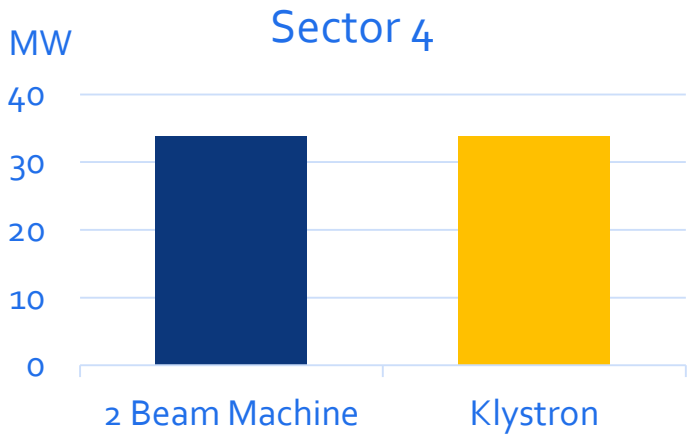


CLiC CV

- Cooling Power

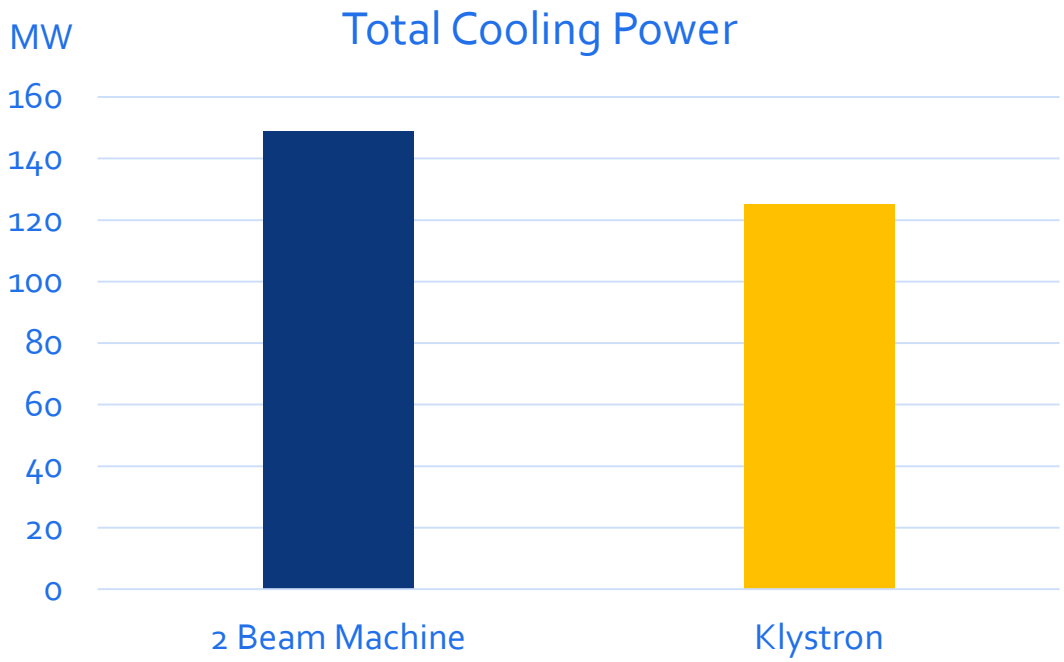






CLiC CV

➢Cooling Power



Future Work

- Cost estimate
- Numbers checking for consistency between teams
- CV detailed report
- Integration of CV infrastructures in the tunnels
- Further technical detailing

Conclusions

- PiP is ready for delivery
- Solid technical solutions for both cooling and ventilation
- There is important work ahead that is relevant to validate and test the technical solutions
  - Integration exercises with CE and all the utilities
  - Temperature stability tests
  - …

Questions and Remarks

Thank You for Your Attention