COOLING & VENTILATION INFRASTRUCTURE

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- Proposed modifications

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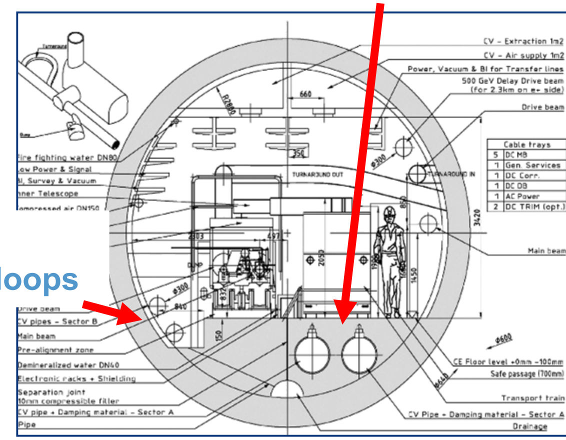
Cooling CDR Baseline

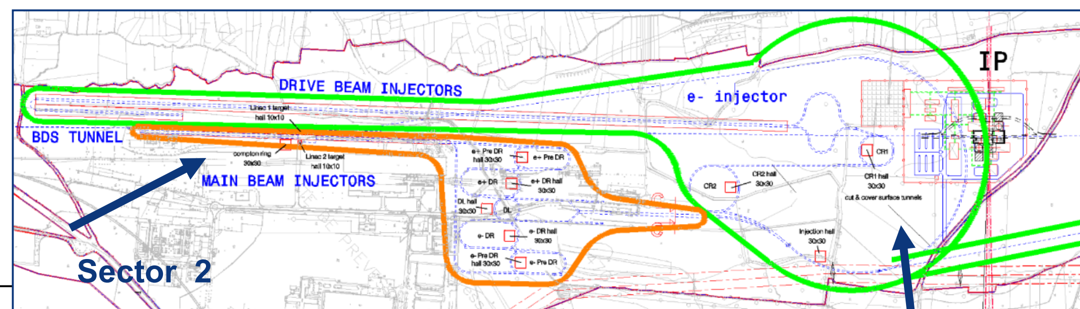
Facilities divided into 5 cooling sectors according to:

- 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

Sector 3
Accelerating structure

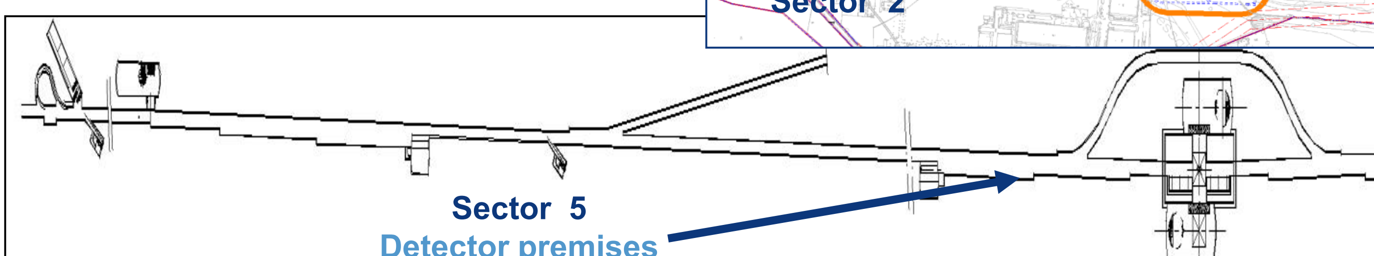
Sector 4
UTRs, dumps, loops





Sector 2

Sector 1

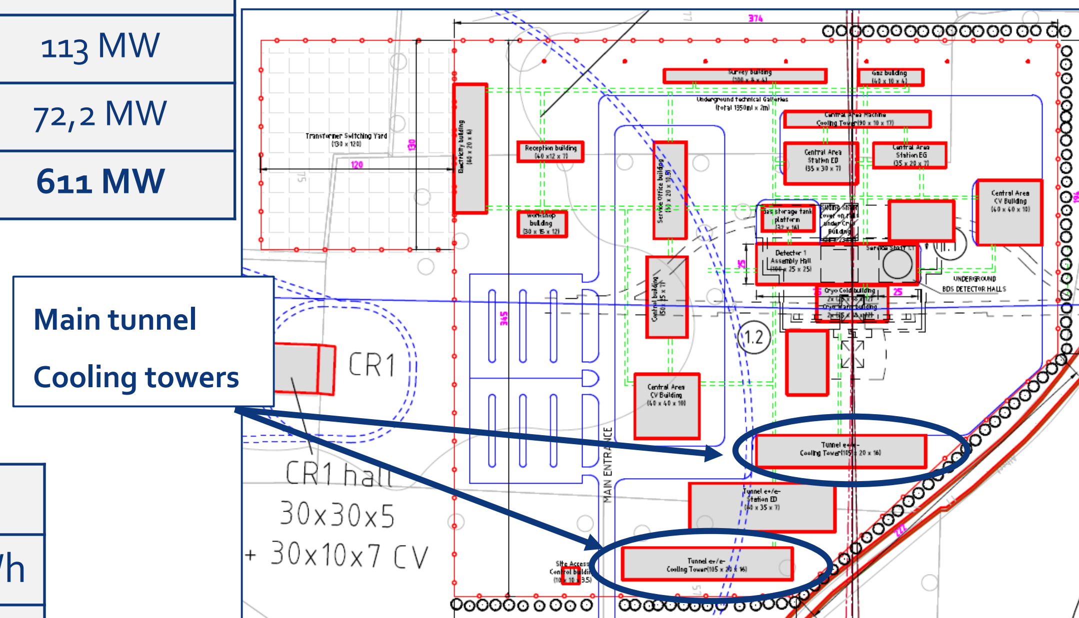


Sector 5
Detector premises

Cooling CDR Baseline

DRIVE BEAM TUNNEL

	Accel. Heat loads	Cooling plant
Sector 1	199 MW	217 MW
Sector 2	63 MW	71 MW
Sector 3	69 MW/side	138 MW
Sector 4	52 MW/side	113 MW
Sector 5	65 MW	72,2 MW
Total	**569 MW**	**611 MW**



Parameters	
Flow rate	28'641 m^3/h
Temperature difference	20 °C
Make-up water*	860 m^3/h

* Average water consumption at CERN: 750 m^3/h

Cooling heat loads

3TeV CDR values

			Power (kW)
Sector 1			**198 960**
	a	Drive beam injectors building	142 560
	b	Drive beam injectors tunnel	15 840
	c	Frequency multiplication	15 581
	d	Transfer lines	8 028
	e	Chilled water production	16 951
Sector 2			**62 922**
	a	Main beam injectors building	14 215
	b	Main beam injectors tunnel	1 465
	c	Surface damping rings	21 634
	d	Tunnel damping rings	16 717
	e	Booster tunnel	1 066
	f	Booster building	5 364
	g	Chilled water production	2 461
Sector 3 (Drive Beam Machine)			**138 000**
	a	Tunnel e-	69 000
	b	Tunnel e+	69 000
Sector 4 (UTRs, dumps, loops,…)			**104 374**
	a	Tunnel e-	52 187
	b	Tunnel e+	52 187
Sector 5			**65 329**
	a	Detector premises	17 000
	b	Accelerator tunnel	41 760
	c	Chilled water production	6 569

New 3 TeV

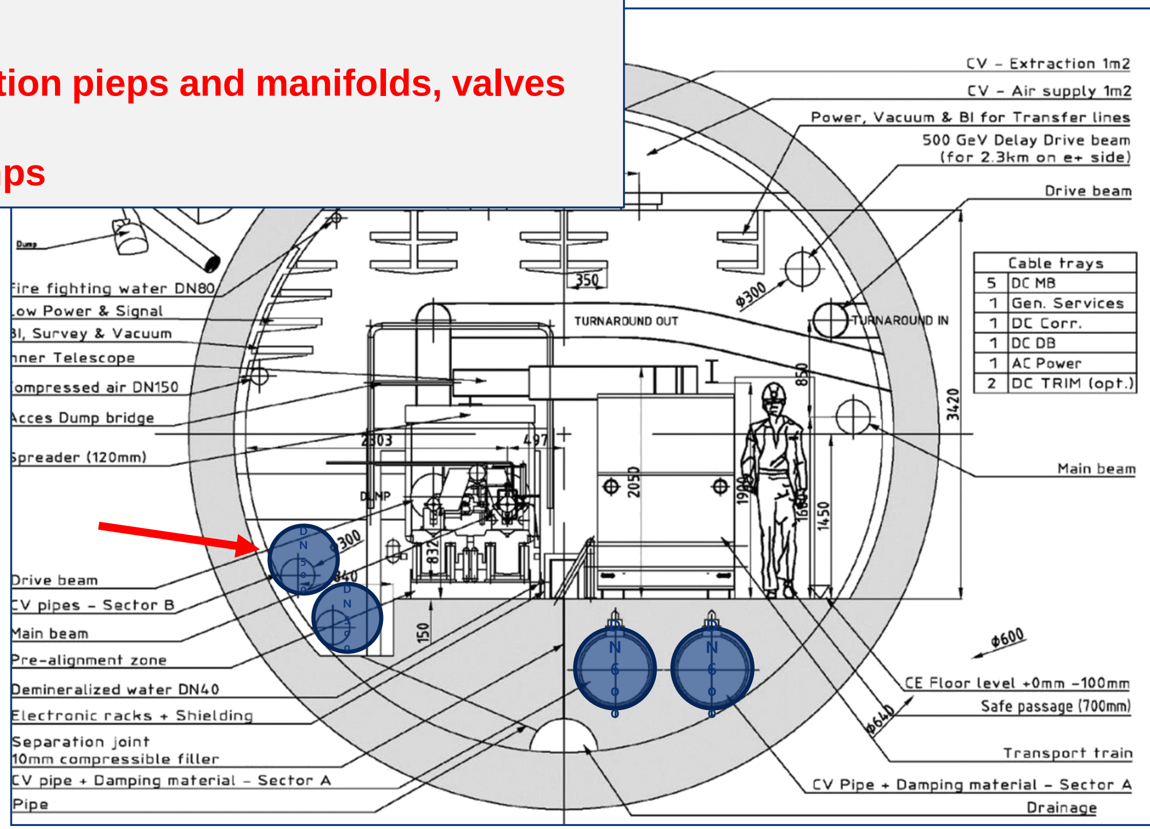
Sector 3 Drive Beam Machine			**115'000 kW**
	a	Tunnel e-	57'500
	b	Tunnel e+	57'500

Updating/confirmation of other values needed

Cooling Issues

Missing items:
- **Fire fighting water**
- **Compressed air**
- **Chilled water**

Open issues
- **Bypass inlet/outlet**
- **Connections between distribution pieps and manifolds, valves**
- **Connections to drains**
- **Need & space for booster pumps**

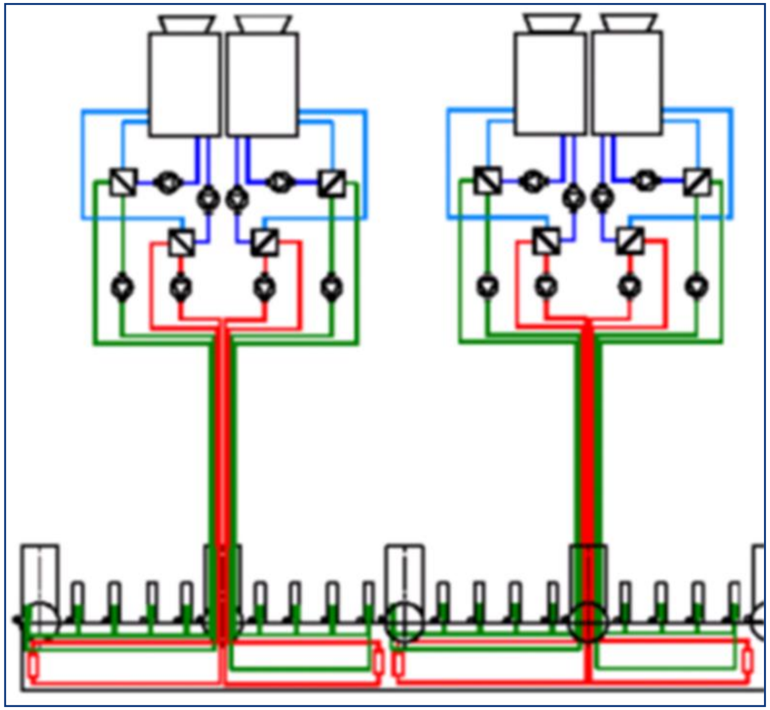


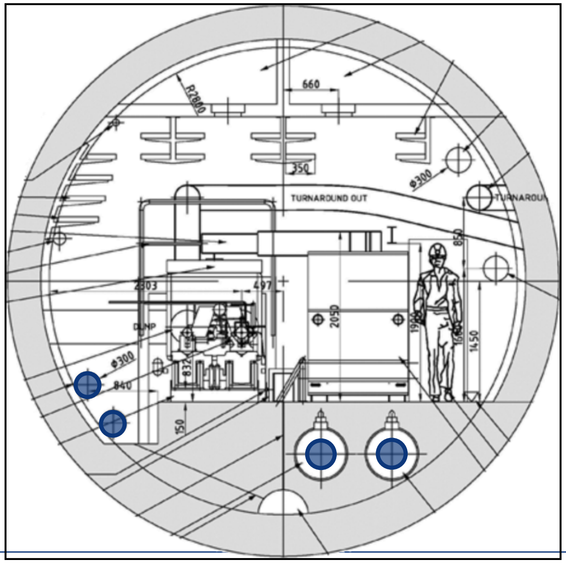
Cooling: proposed modification

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, …)





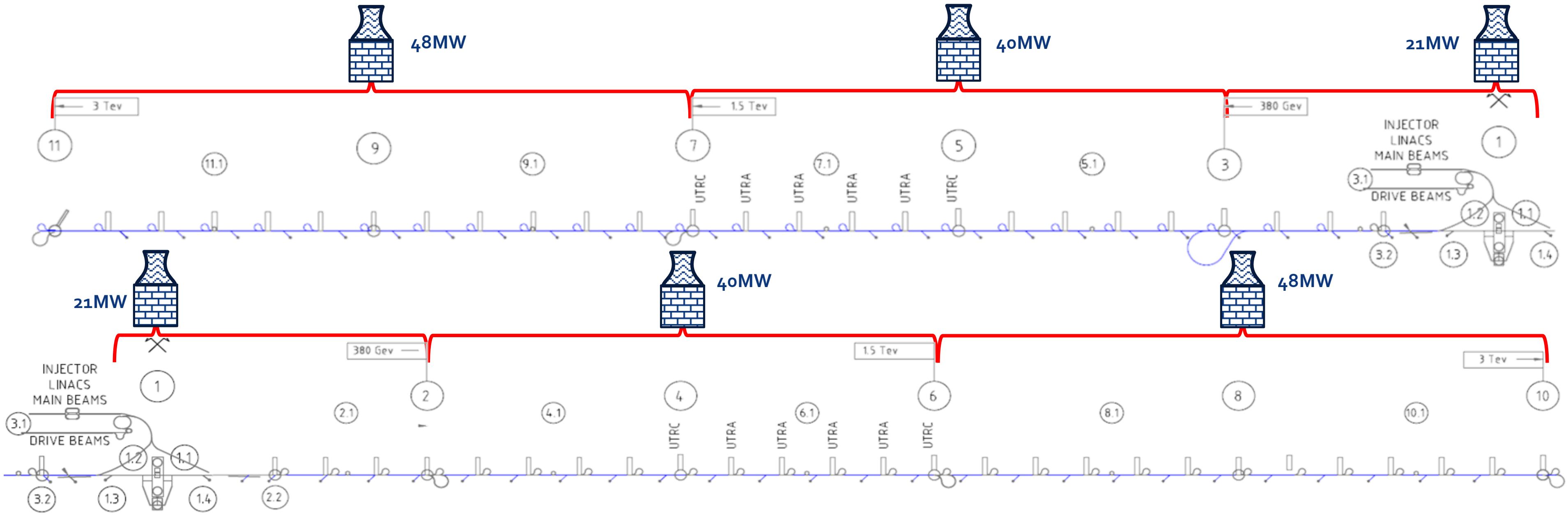
Disadvantages:

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

However: manifold issue still present

Cooling: possible solutions

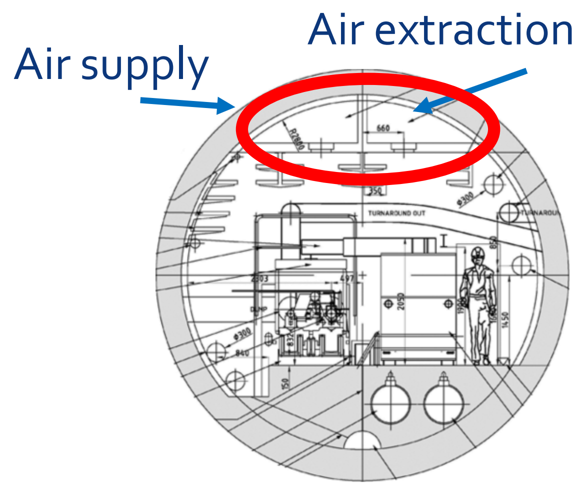
Cooling towers in surface points: Pt 4, 5, 8, 9



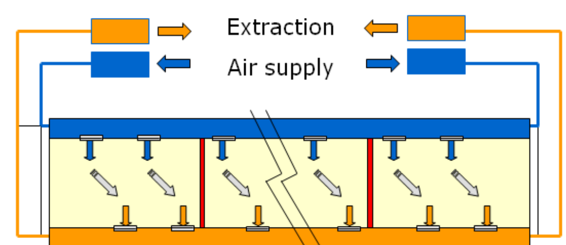
Ventilation CDR

Indoor conditions

Location	Summer conditions [°C]	Winter conditions [°C]
Underground installations	21±1	21±1
Surface buildings with controlled temperature	25±1	18±1



- **Ventilation of main beam tunnel:** supply & extraction located at each surface point
- **Ventilation of UTRC, UTRA, roundabouts, dumps**: dedicated AHUs installed in UTRA or UTRC caverns. Chilled water from surface points
- **Damping rings, delay loops, frequency multiplication, transfer lines**: one AHU for supply and one for extraction per ring or sector. Relay fans for dead end tunnels.
- **Drive beam injectors tunnel:** supply and extraction located on surface
- **All others**: one dedicated unit per facility



Semi-transversal ventilation

Ventilation heat loads

3TeV
Old values
(CDR)

	Equipment heat load [kW]
Tunnel Drive Beam injector	1760
Tunnel Main Beam injector	380
Damping rings	950
Tunnel booster LINAC	100
Transfer line to JP, SP	450
Loop	230
Transfer line e$^-$	0
Transfer line e$^+$	0
Frequency multiplication	405
Main tunnel* e$^+$	528
Main tunnel* e$^-$	528
Turnaround e$^-$ and tunnel	35
Bunch compressor e$^-$	35
Turnaround e$^+$	35
Bunch compressor e$^+$	35
UTRC	95
UTRA	95
Drive Beam dump caverns/ post decelerators	5
Loop	10
BDS - intersection point	1560
Detector halls	650
Main beam dump cavern	140
Service halls cavern (pt 2.2 and 3.2)	150
BC2 caverns	20
Bypass tunnel	0
Escape tunnel	0
Pressurized area shaft	0

* per sector, between two surface points

Surface building	Equipment heat load [kW]
Drive beam Linac	15 840
Main Beam Linac Hall	608
Linac 1 and 2 target halls	0
Compton ring	0
Damping rings area (5 buildings)	0
Booster linac	0
Injection hall	170
Combiner ring 1 & 2	380
Cryo building	n.a.
Gas building	n.a.

Updating/confirmation of other values needed

No new values except for power dissipation to air by the accelerating structures.

3TeV
New values

	W/m	Total sector
CDR	144	528 kW
New	538	11,5 MW

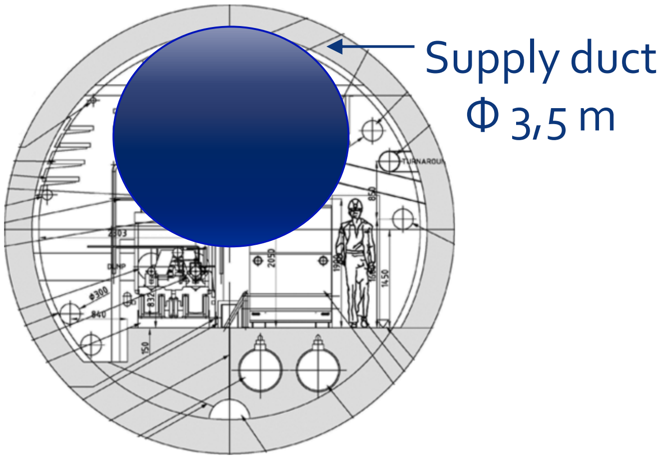
Duct size [m2]	Q [m3/h]	ΔT [°K]	Cooling power/sector [kW]	Heat load [W/m]
1	72'000	10	250	47

Ventilation main tunnel: heat load

- Technical loads not compatibles with achievable flow rate for the tunnel (duct size)
- Semi-transversal ventilation does not act directly on the source of the heat
- Smoke extraction to be taken into account

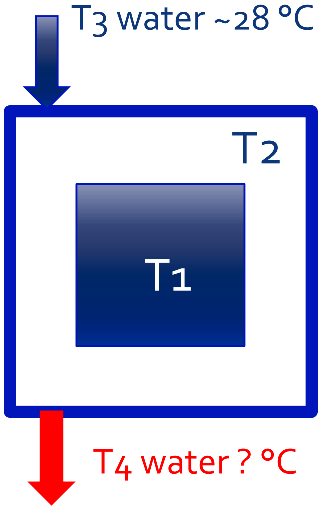
T max in tunnel [°C]	ΔT [°K]	Q [m3/h]	Φ duct [m]
21	4	886'000	4,0
26	9	838'000	3,5
30	13	580'000	3

LHC sector: 36'000 m3/h



Ventilation: possible solutions

A possible solution would be a combination of:



1. Increasing the allowable temperature in the tunnel to reduce the heat load to air e.g. to 30°C. → working environment
2. Supplying fresh air through a duct coming from each surface point, dissipating part of the heat load. The air would return through the tunnel and the shafts. → gradient of temperature along the tunnel
3. Cool the air locally and not discharge the heat in the tunnel:
   a) Encapsulating the modules:
      1. Installing heat exchangers with an additional cooling circuit to reduce the load on the air/become neutral to the tunnel ambient,
      2. Installing fans inside the "box" forcing the air inside it through small heat exchangers connected to an additional (chilled) water network

   b) Additional units all along the tunnel → issues wit space, air direction, effectiveness of the solution

Separate the tunnel ventilation from the heat load removal f

Conclusions

Cooling infrastructure

- The CDR solution of centralising all cooling towers in the center results in huge pipes and need of booster pumps plus other technical problems.
- Best solution would be to install cooling towers in some surface point for the main tunnel.
- Updates of heat loads from all users is needed.
- Don't forget other services (compressed air, fire fighting water, etc.) for the definition of the cross-section.

Ventilation infrastructure

- A tunnel ventilation only (as in the CDR) is not adapted for the huge air loads inside the main tunnel.
- Different solutions to be evaluated in order to increase acceptable loads:
    1. Increase the allowable temperature in the tunnel
    2. Insulate the CLIC modules
    3. Encapsulate the CLIC modules
    4. Install AHU machines to tackle the heat load more locally
- The final solution would include a combination of the previous.
- The smoke extraction and radiation protection systems need to be taken into account.
- Updates of heat loads from all users is needed.

THANKS FOR YOUR ATTENTION