Development of Cooling and Ventilation systems for FCC and HE-LHC

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FCC Week, 11th April 2018

Content

- Ventilation
  - FCC tunnel hh & ee
    - *Additional Safety Constraints and solutions on Smoke Extraction*
  - HE-LHC
    - *General description of the ventilation system*
    - *In case of smoke detection*

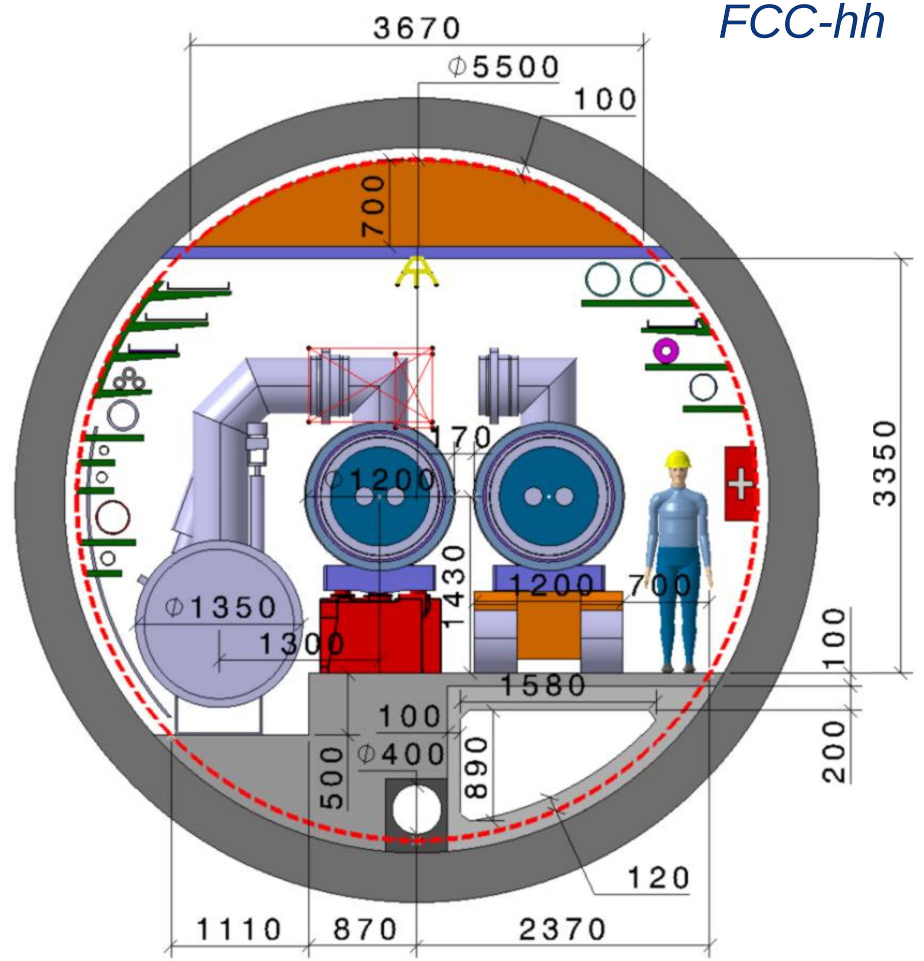
- Cooling
  - FCC Cooling towers
    - *General solution/architecture*
    - *Reject water treatment*
    - *Makeup water*
    - *Environmental constraints*
- Other cooling systems:
  - Demineralised water
  - Chilled water

Conclusions

Ventilation of the FCC tunnel

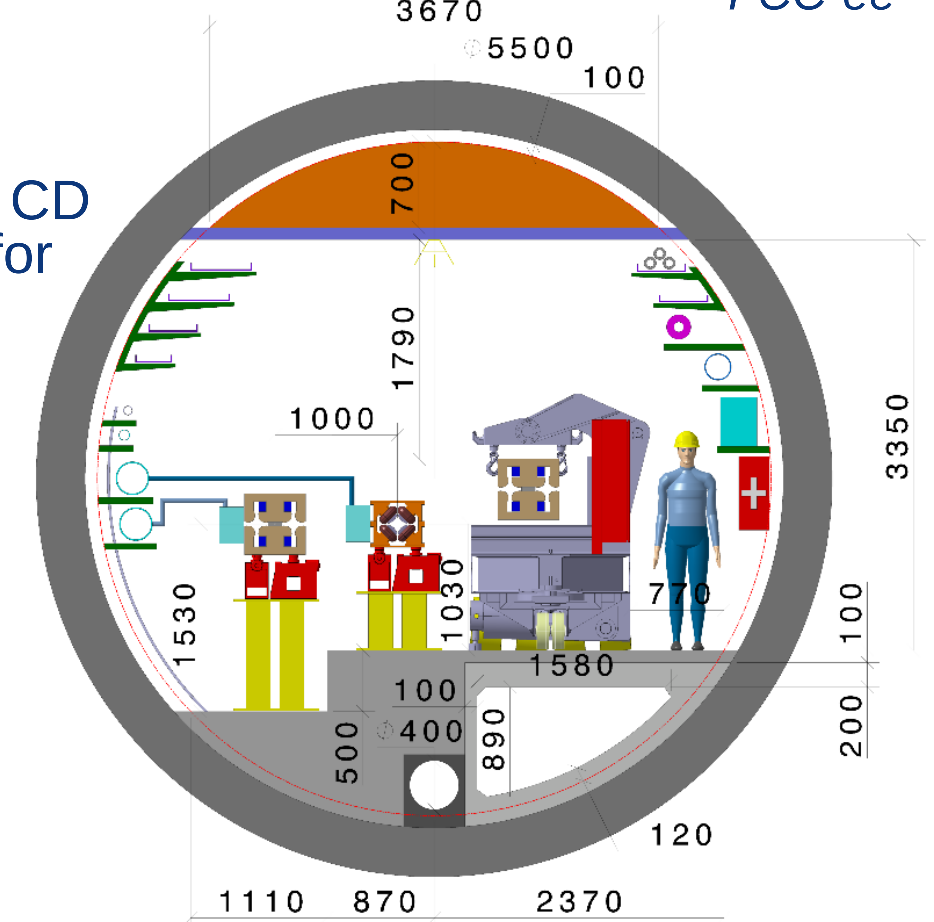
			From	To
Geometry	*Tunnel Diameter*	[m]	6	5.5
	Cross section for air passage	[m^2]	17.7	15.2
	Volume of a 440 m compartment	[m^3]	7788	6688
Flushing time		[h]	1.9	1.6
Max. air velocity		[m/s]	0.78	0.91

FCC-hh



Ventilation of the FCC tunnel: Heat Loads

- FCC-hh:
  - The heat loads maximum values about 240 kW for sectors CD and JK – no change
  - Air flow from both sides, 2 x 25000 m^3/h
- FCC-ee
  - The heat loads max. values about 500 kW for sectors CD and JK (mainly from magnets and lumped absorbers for SR)
  - A dedicated cooling of the air is needed,
    - by chilled water from 2 points of the sector,
      → DN80 insulated pipes in the tunnel or
    - by refrigerating machines in alcoves,
      - condenser cooled by demi water,
      - many drawbacks (room, radiation environment, maintenance,…)



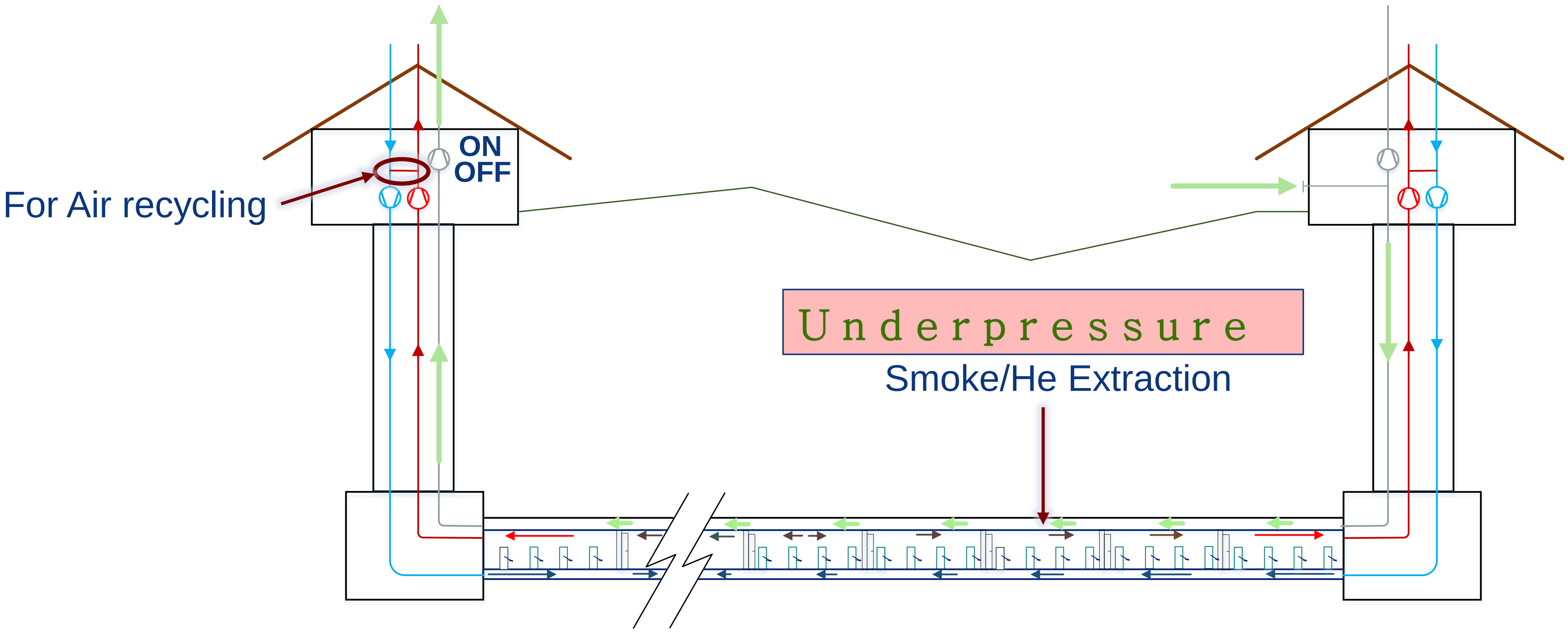
Ventilation: new safety constraints

- Smoke extraction, recent additional requirements:
  - Fast reaction from the smoke extraction system
  - Fresh Air Supply in the affected and neighbouring compartments
    - About 7000 m^3/h in the affected one(s) and 3500 m^3/h in the two neighbouring ones, the same for the extraction

    → from 2 x 25000 m^3/h to 2 x 31500 m^3/h

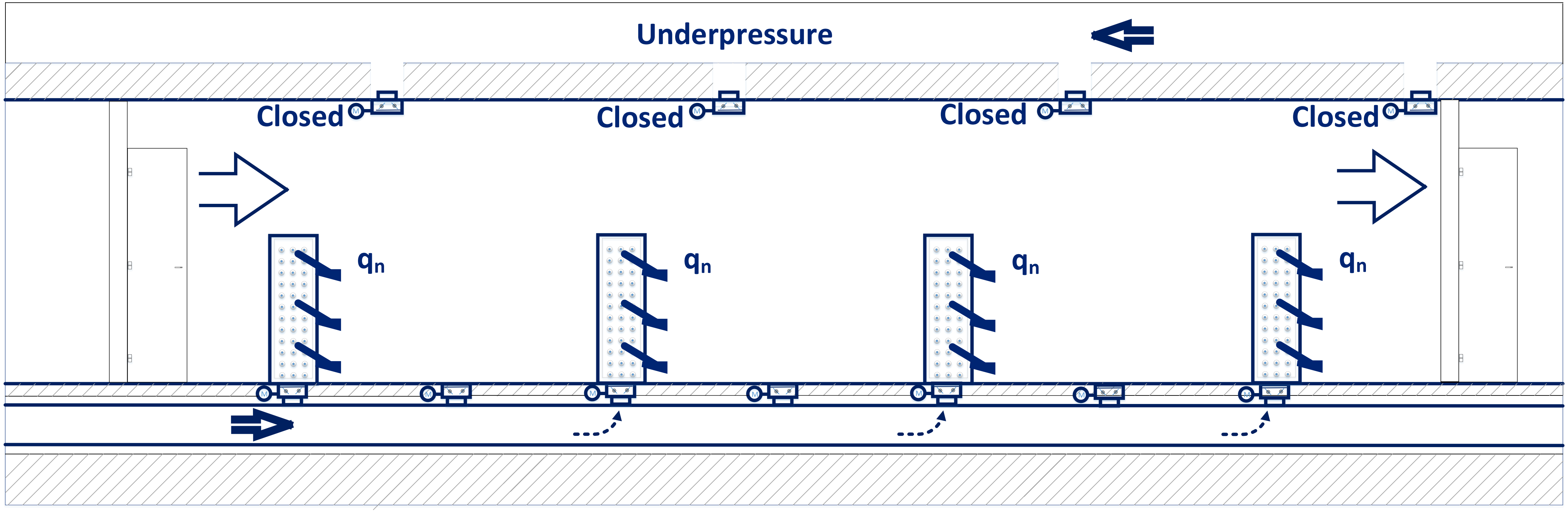
FCC tunnel ventilation in normal conditions

- Ventilation scenario in 2017
- To reduce the smoke extraction system reaction time:
  - One fan would be on, extracting air from the other end of the sector
  - Smoke extraction duct underpressurized, ready for an emergency situation



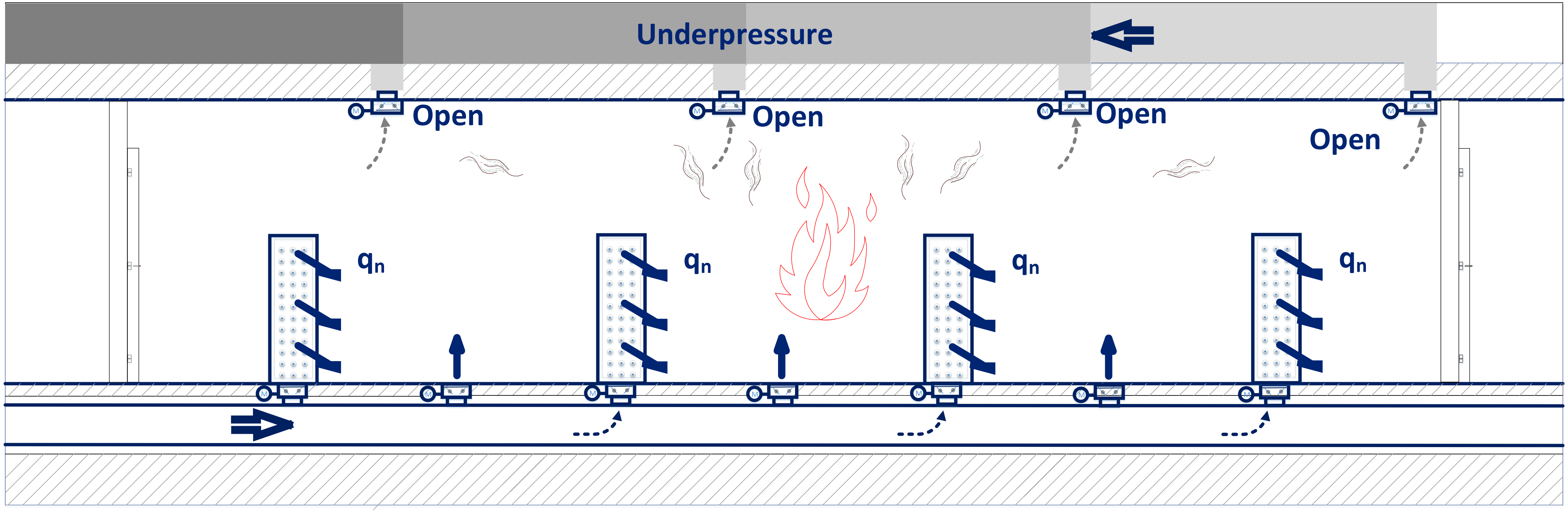
Ventilation of a compartment (I)

- In normal conditions

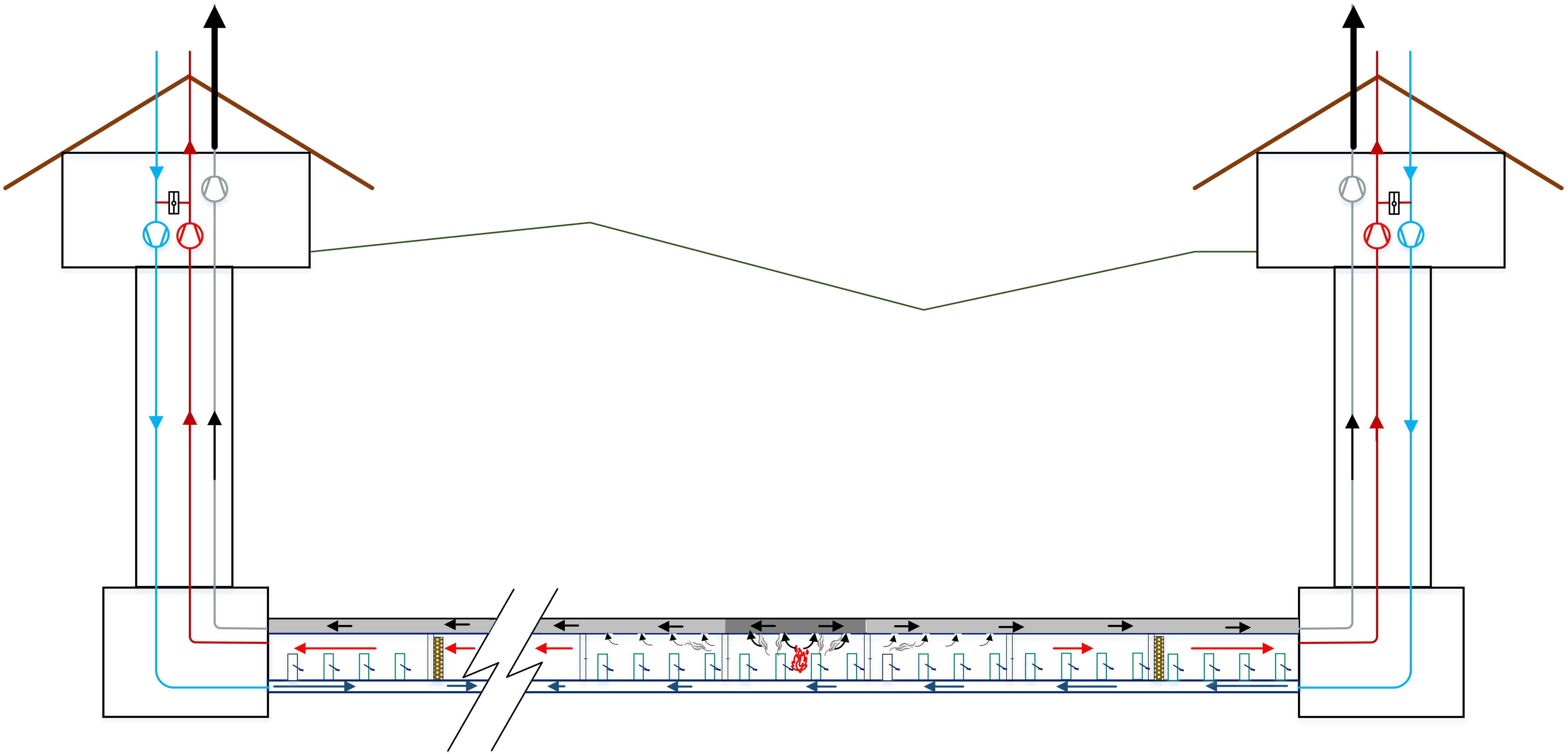


Ventilation of a compartment (II)

- In case of smoke

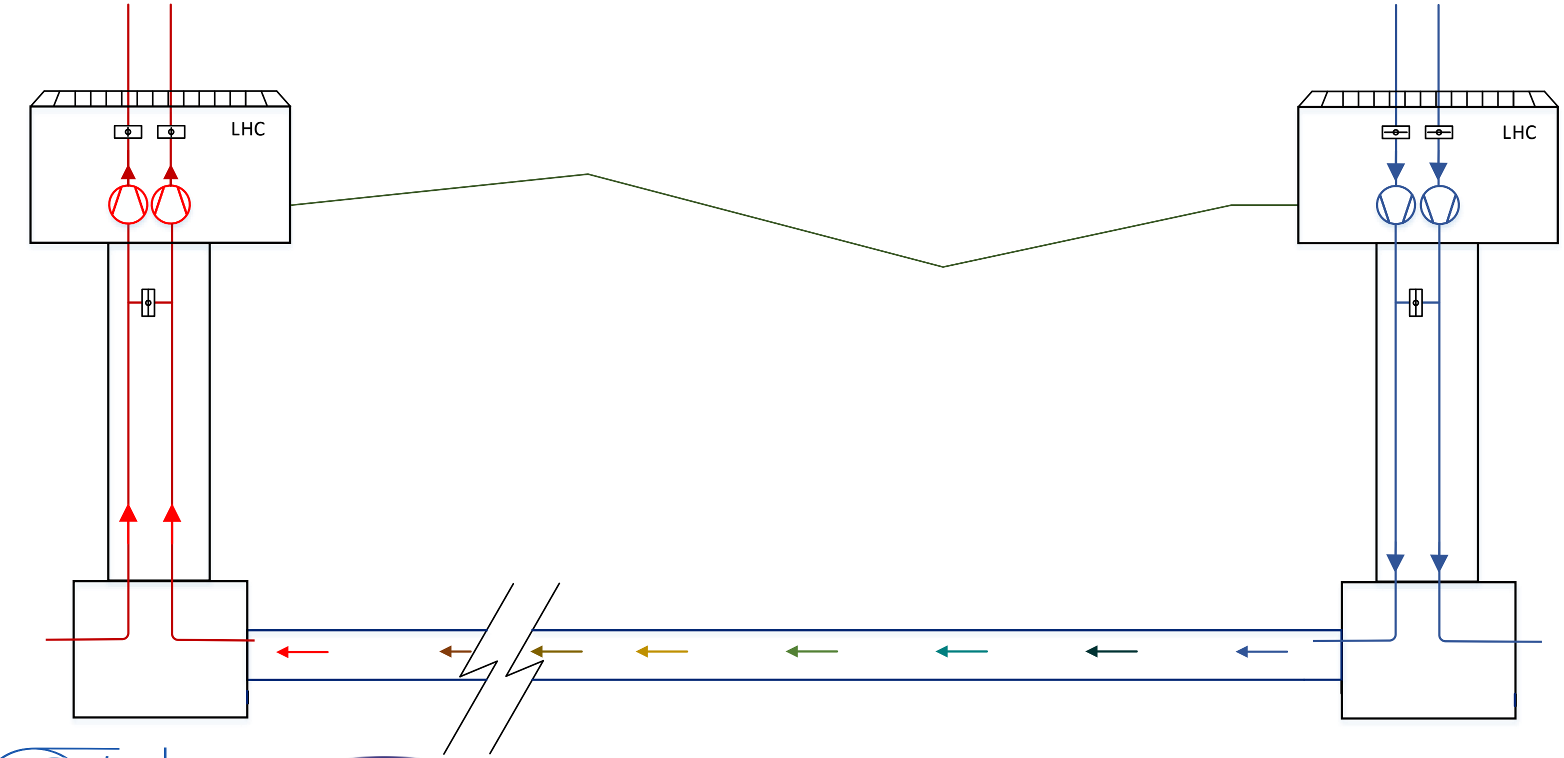


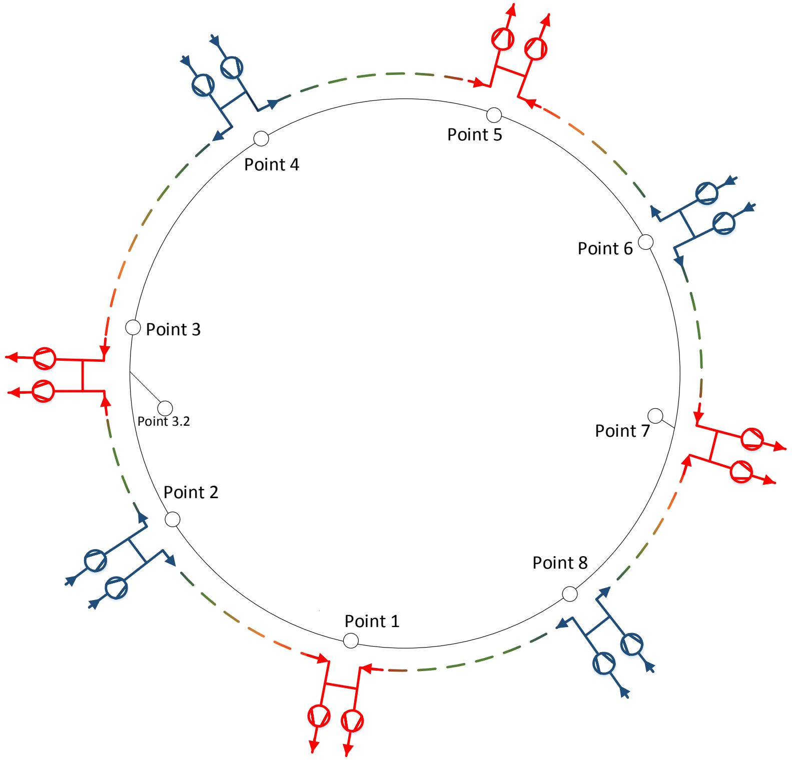
FCC Sector: Ventilation in case of smoke



Ventilation of the LHC in normal operation

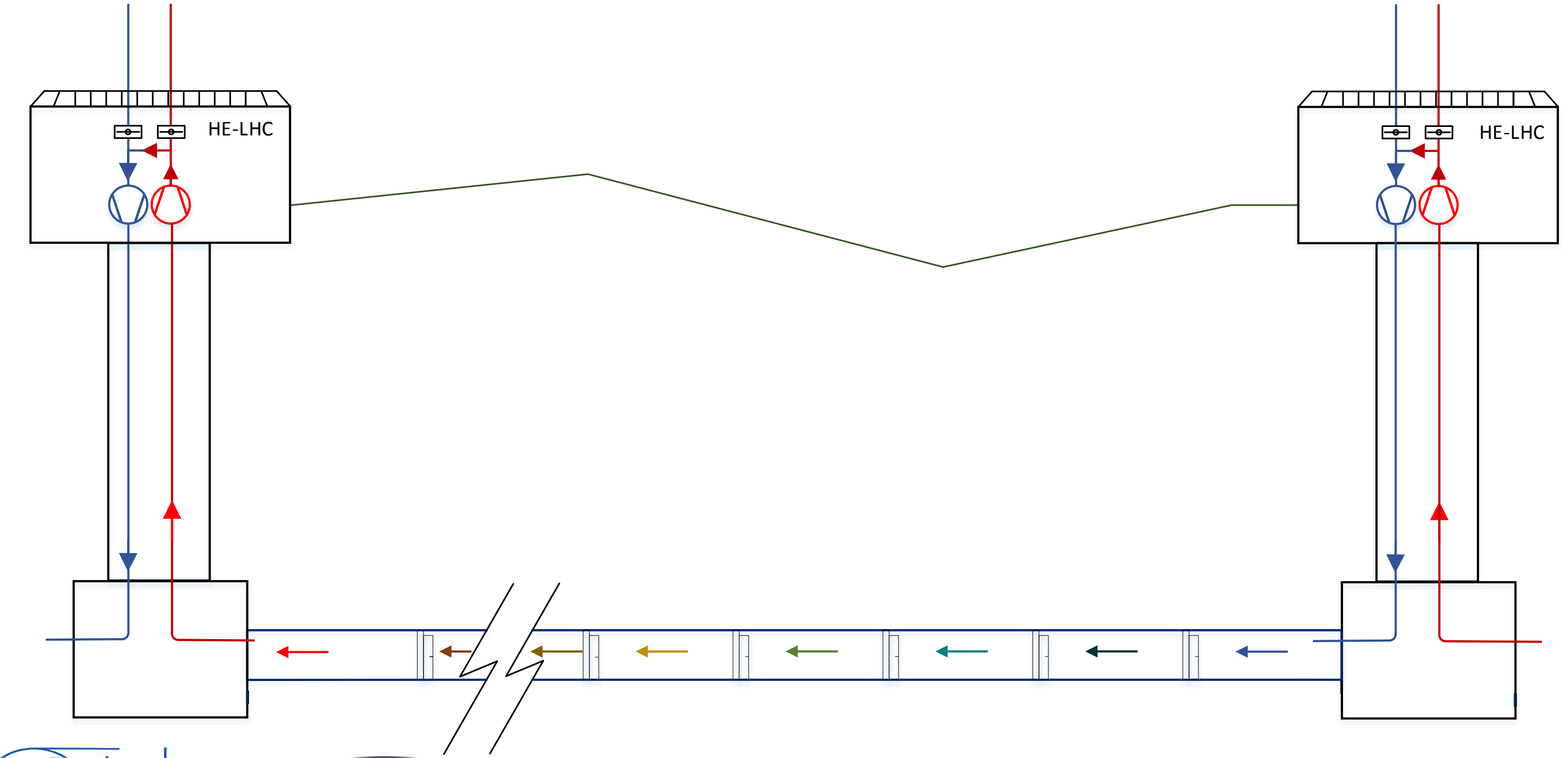
- At present in LHC, 100% fresh air is supplied at the even points and extracted at the odd points,
  - Each unit at one point is back-up of the other unit

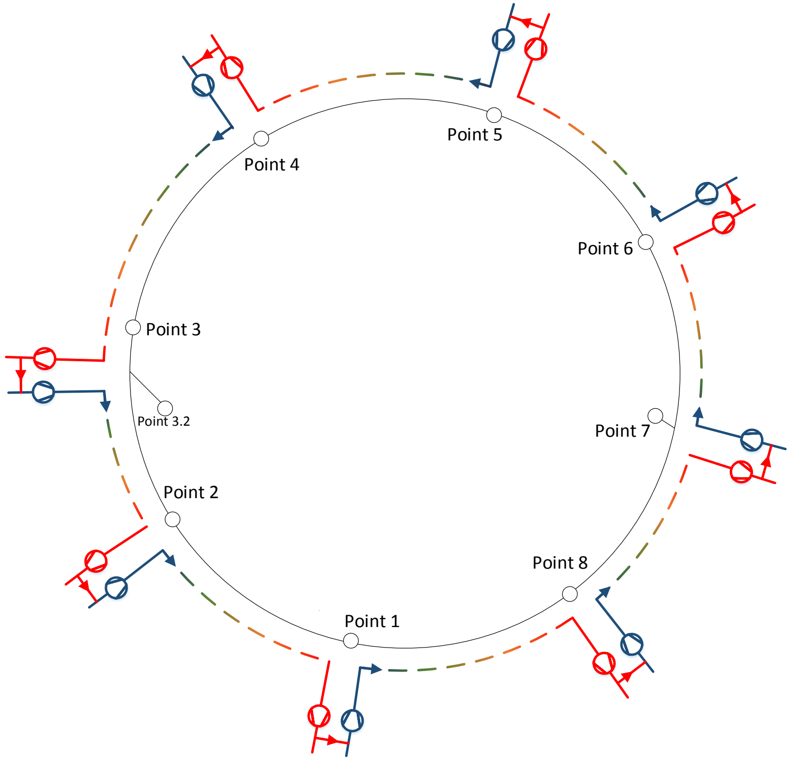




Ventilation of the HE-LHC in normal operation

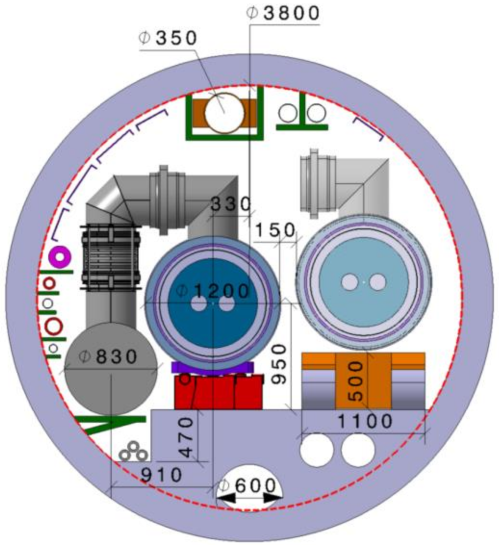
- For energy savings, the air in HE-LHC circulates around the accelerator:
  - The exhaust air from a sector is treated and sent back to the adjacent sector
  - As supply and extraction is done at each point, a unit plus its back-up needs to be added at each point

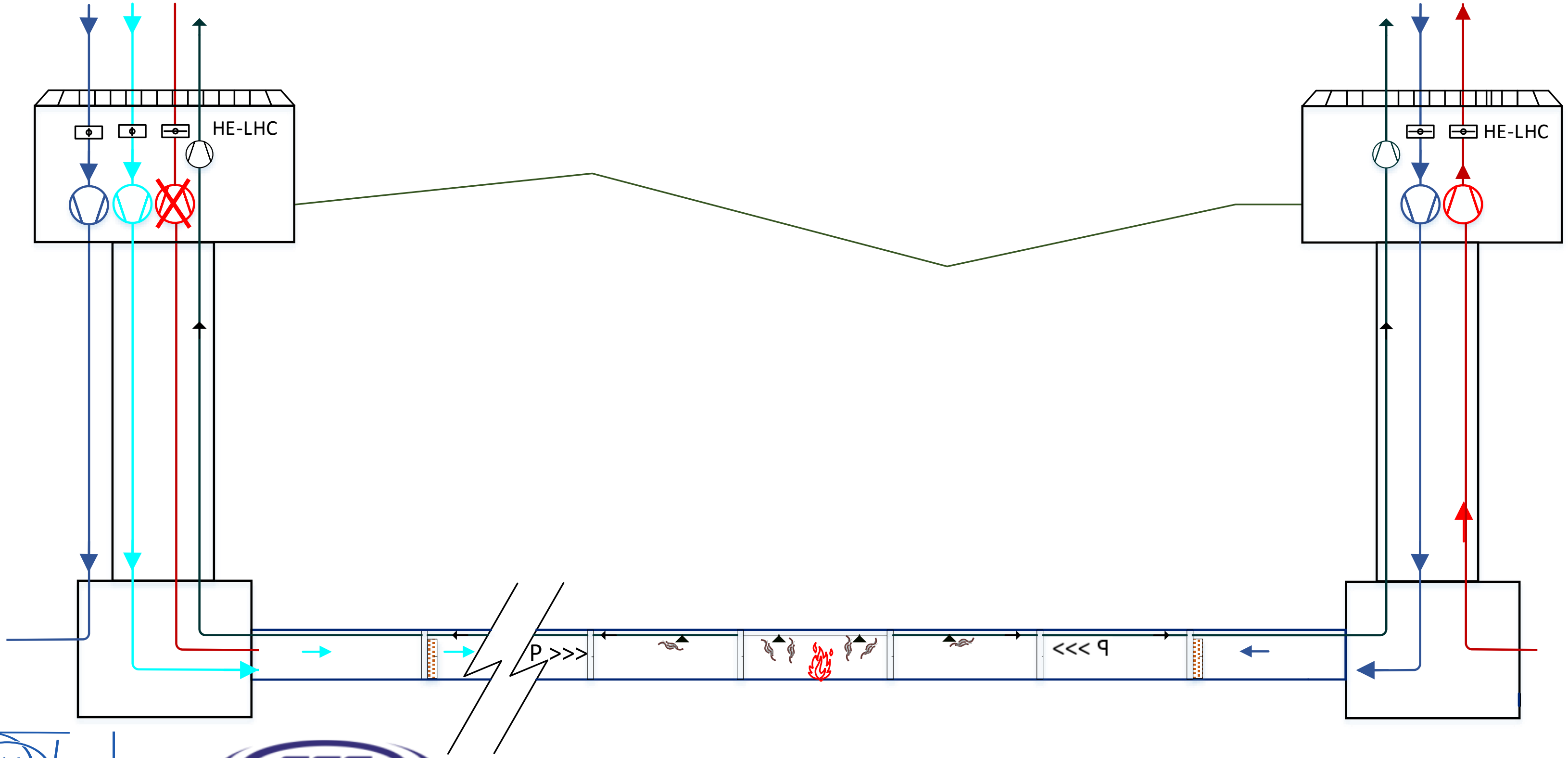


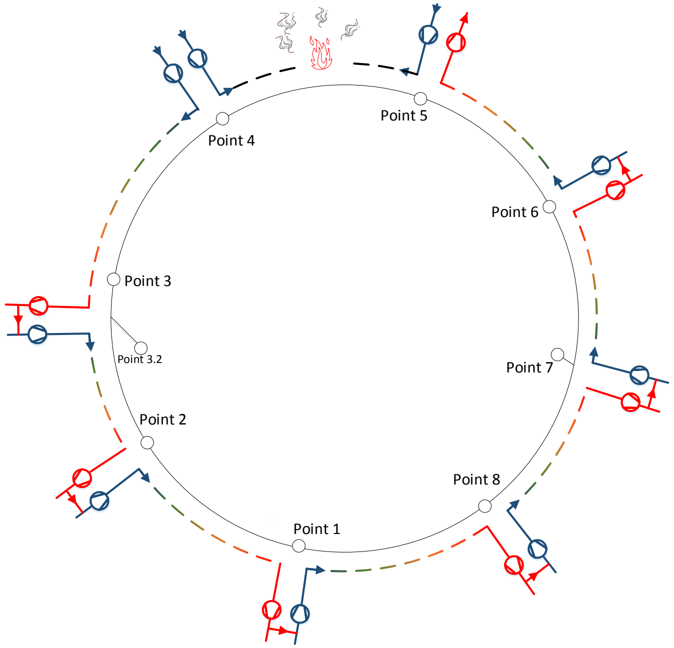


Ventilation of the HE-LHC in case of smoke detection

- The doors of the affected and neighboring compartments close.
- The extraction for the affected sector is stopped and the backup air handling unit supplies air to pressurize the sector from both points.
- The emergency extraction unit extracts a small flow rate from the affected compartments to maintain the pressure cascade.



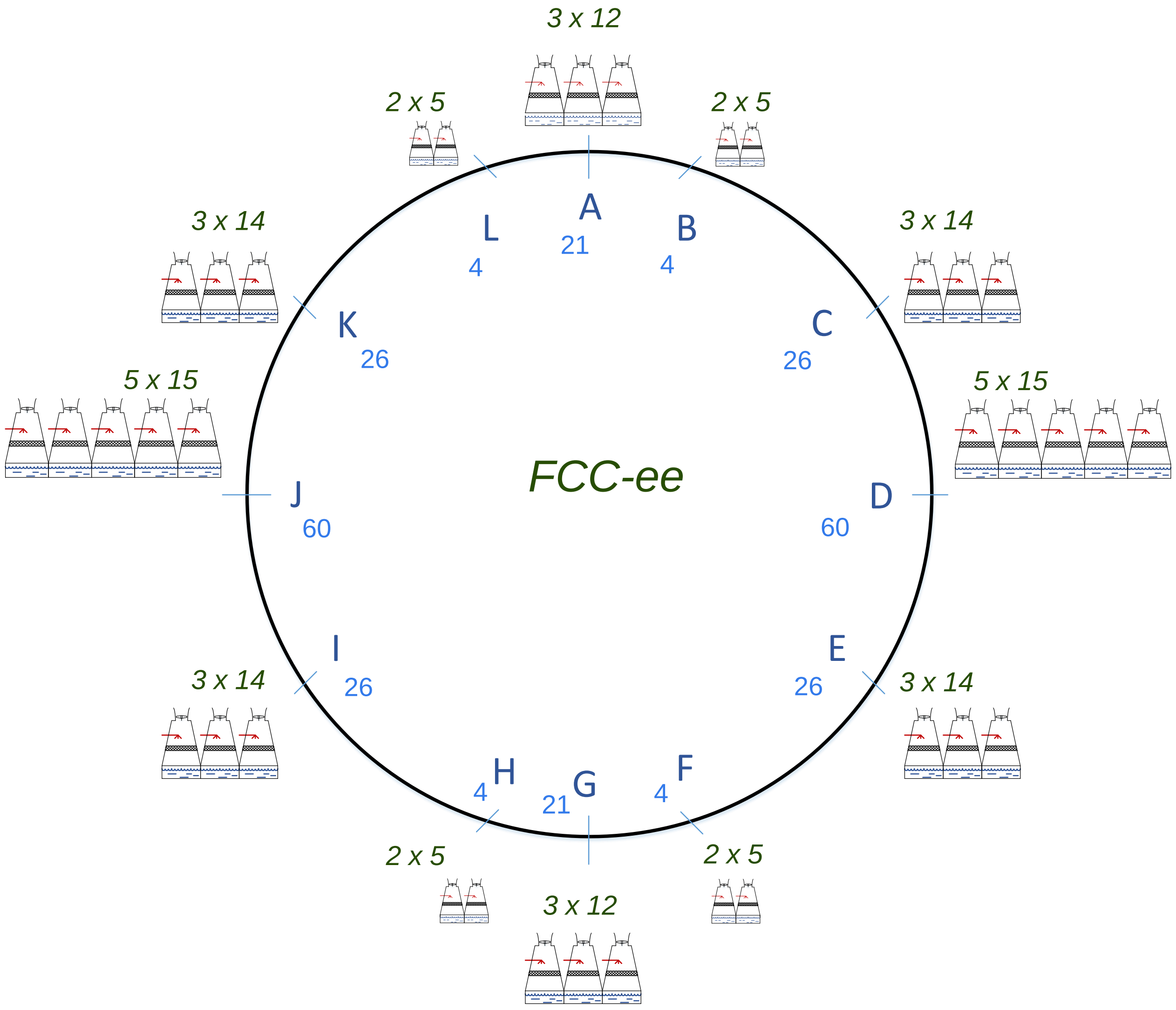




Cooling

- Cooling
  - FCC Cooling towers
    - *General solution/architecture*
    - *Reject water treatment*
    - *Makeup water*
    - *Environmental constraints*
- Other cooling systems:
  - Demineralised water
  - Chilled water

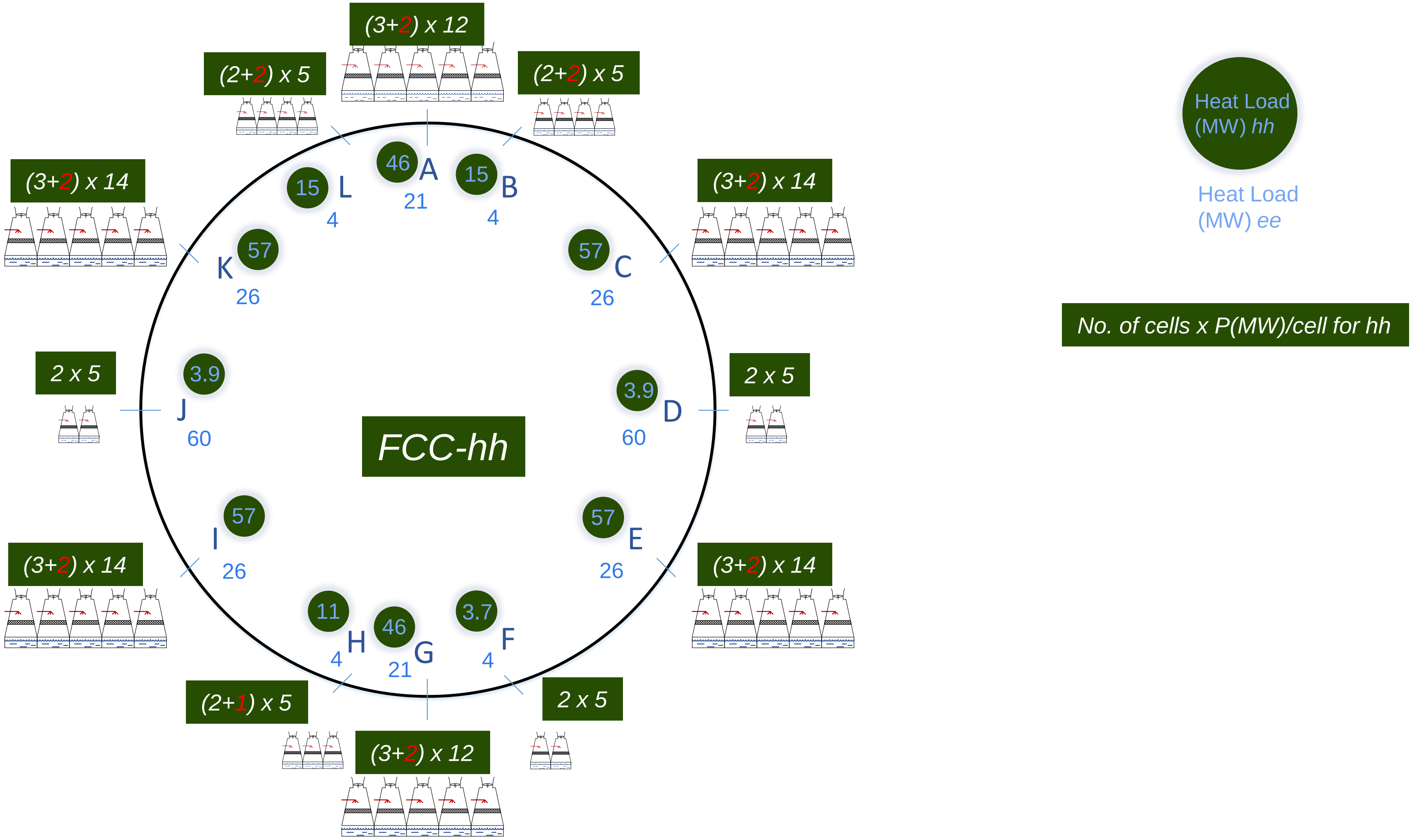
Cooling towers needs in FCC-ee



Heat Load (MW) *ee*

No. of cells x P(MW)/cell for ee

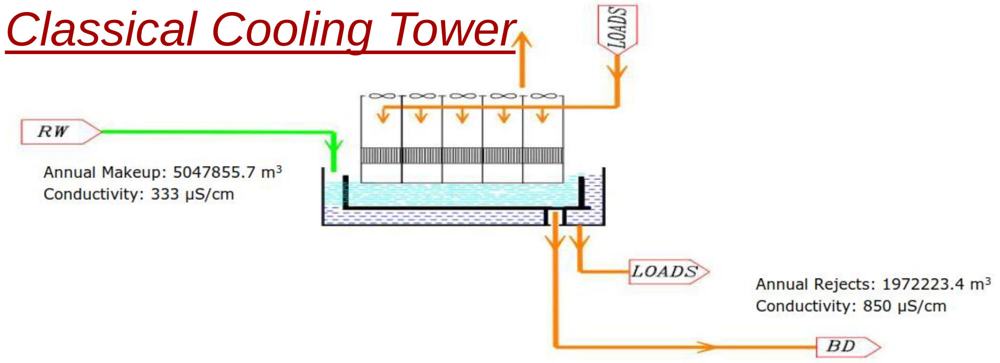
Cooling towers needs in FCC-hh



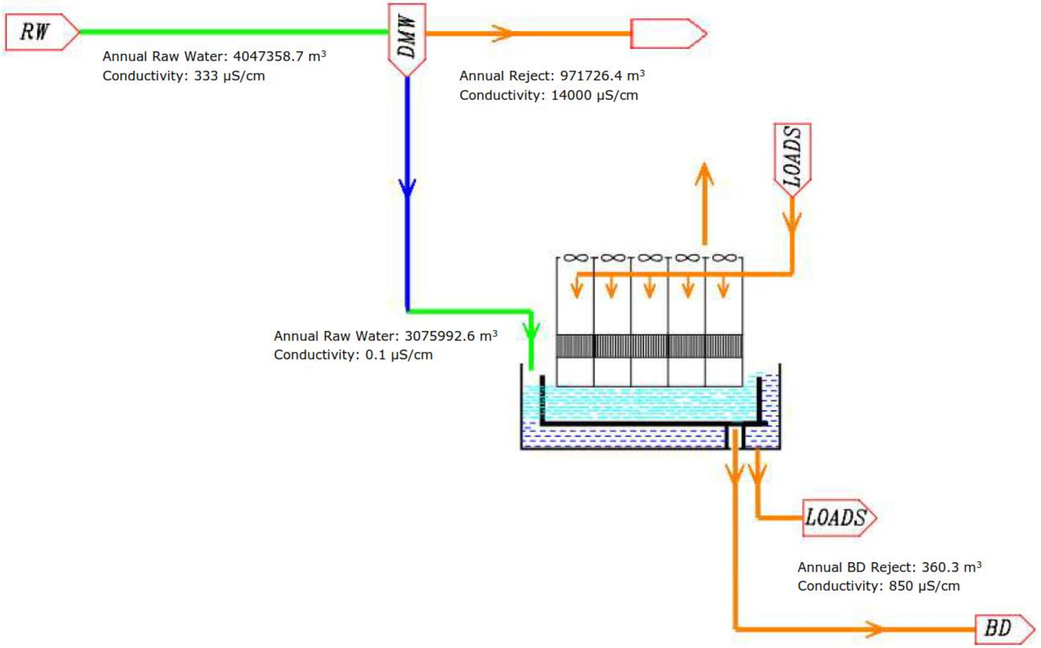
Reduction in Blowdown and Make-up water Consumption

- Calculations show that, for heat loads of FCC-hh, the evaporated water in the cooling towers amounts to about 3 Mm^3 / year
- In case of *Classical Wet Cooling Tower*, the overall water consumption will be of 5 Mm^3 / year with a blowdown of 2 Mm^3 / year
- Two other options are proposed:
  - *Make-up with demineralised water* (0.1 μS/cm)
    - For secondary cooling circuits, a demineralised water production plant is needed for each point. The same plant can be used for make up water
    - Stainless steel circuits and mixing are needed
    - 20% Reduction of overall water consumption
  - *Recycling blowdown water*, reducing TDS by Reverse Osmosis, to 20 μS/cm
    - Dedicated process is needed
    - 34 % Reduction of overall water consumption

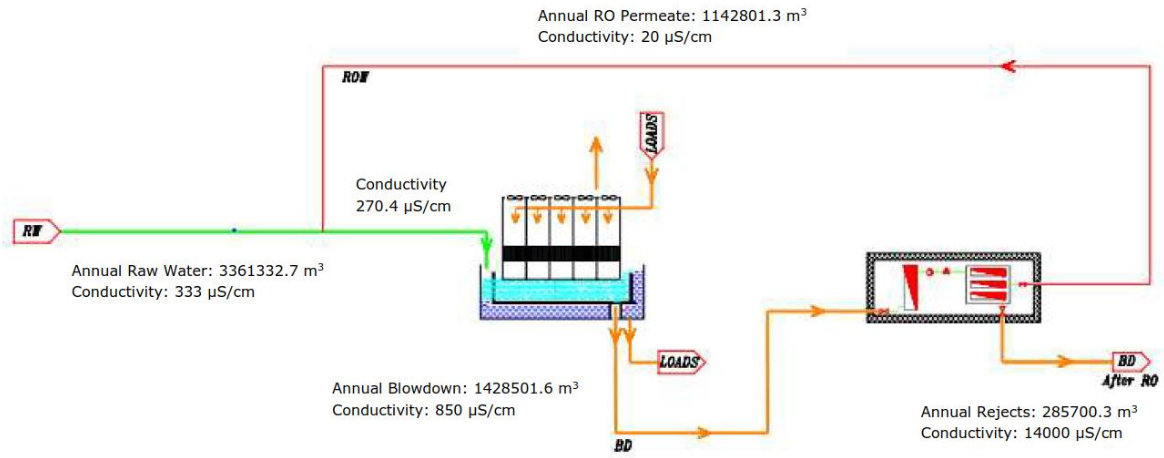
Classical Cooling Tower



Make-up with demineralised water



Recycling blowdown water



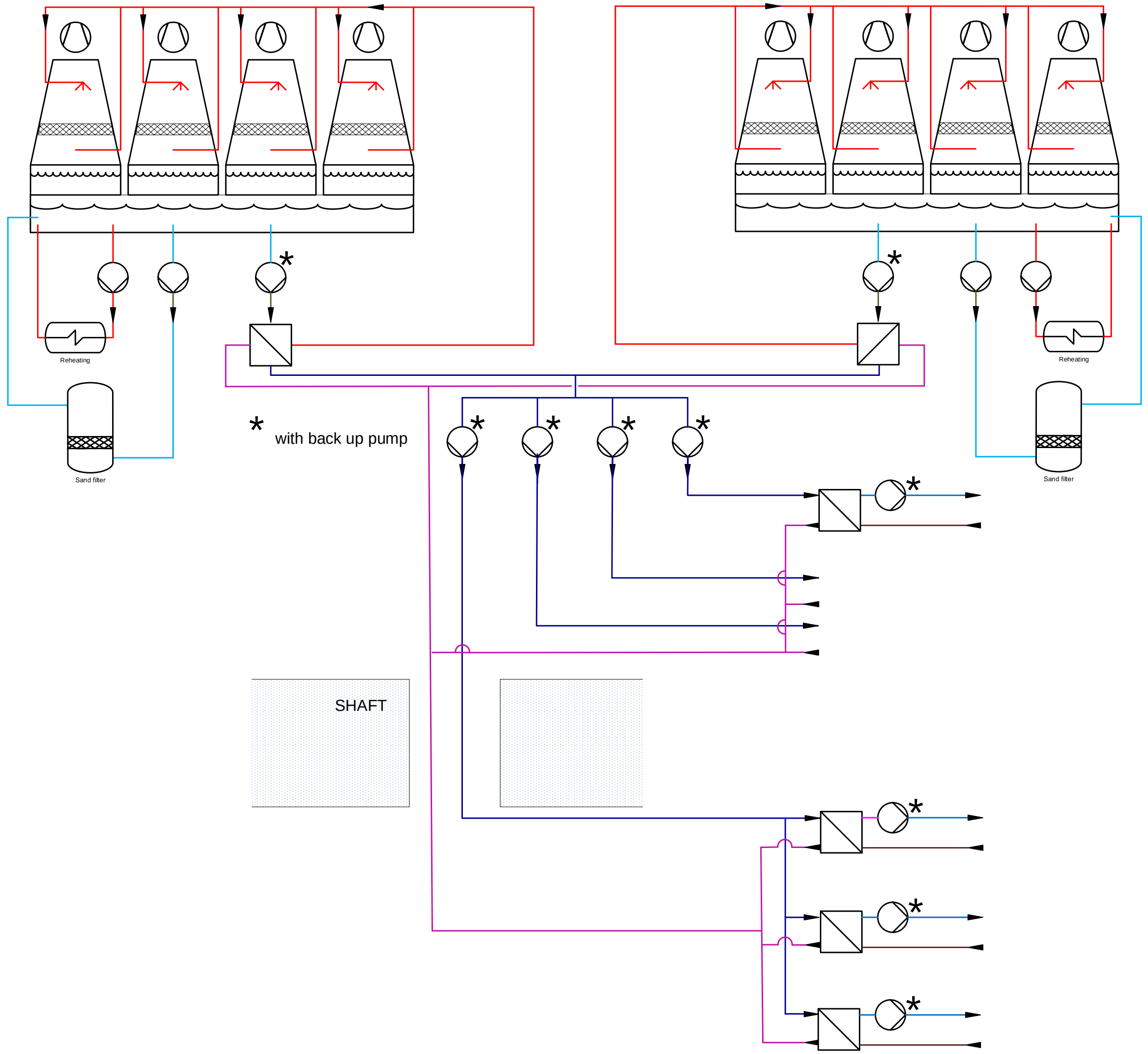
Cooling Towers: **Regular Cleaning**

- Following applicable laws and standards, actions taken for regular cleaning:
  - Preventive maintenance:
    - *Annual Mechanical Cleaning for accessible surfaces,*
    - *Annual Chemical Cleaning for all surfaces,*
    - *Chemical water treatment.*
  - Monitoring plan: monthly analysis of bacteria concentration in the water.

- When annual cleaning is not possible for technical or economical reasons, compensatory measures are taken:
    - Keep under control phenomena like biofilm or deposits (scale formation) or bacteria nutritional elements,
    - Keep bacteria concentration low,
    - Survey the installation.

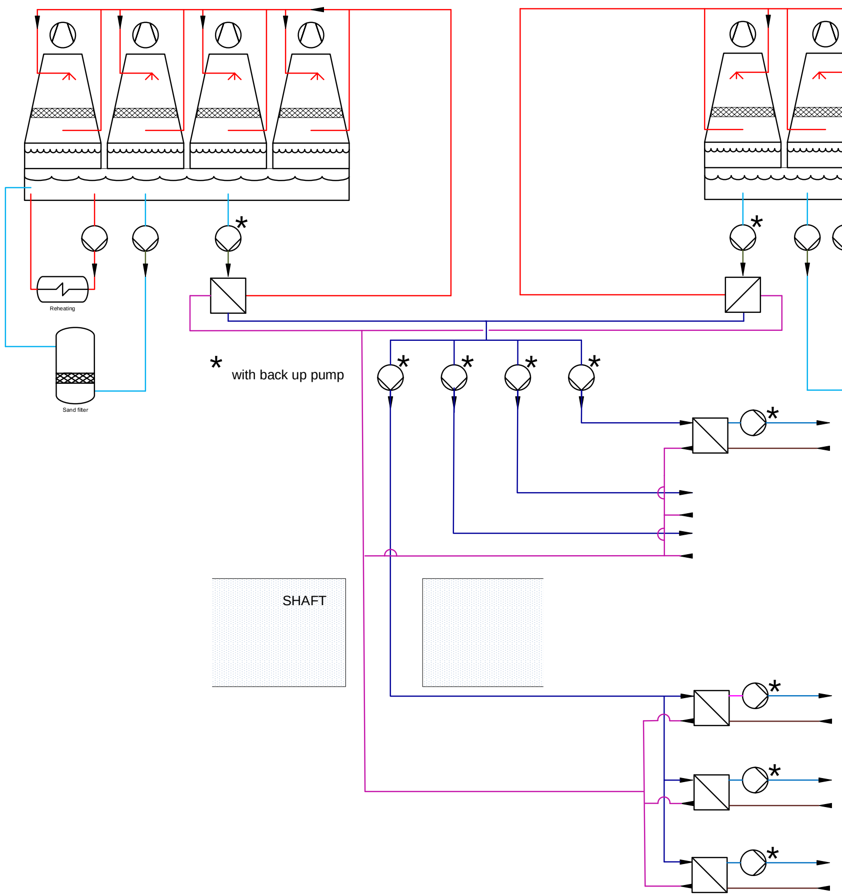
Double Cooling Tower Circuit, Option 1

4 season back-up solution



Double Cooling Tower Circuit

Normal CT | Winter back-up CT



Wet Bulb T (ºC)		Avg	Std	Min	Max	95% L	95% H
Cold Season	Dec.	1.6	3.6	-13.1	12	8.7	-5.6
	Jan.	0.6	3.7	-18.7	11.6	8.1	-6.9
	Feb.	0.9	3.8	-17.2	10.9	8.6	-6.8
Mid Season	Mar.	3.9	3.7	-10.5	14.1	11.3	-3.5
	Apr.	6.8	3.3	-5.2	16.3	13.4	0.2
	Oct.	9.4	3.5	-4.6	17.7	16.3	2.4
	Nov.	4.4	3.6	-9.4	14.5	11.6	-2.9
Hot season	May	10.8	3.2	-0.3	20.4	17.2	4.4
	Jun.	13.8	3.2	2.3	22.5	20.2	7.4
	Jul.	15.6	2.8	5	22.6	21.1	10.1
	Aug	15.4	2.8	5.2	22.7	21	9.8
	Sept	12.7	3.1	1.1	21.4	18.8	6.5

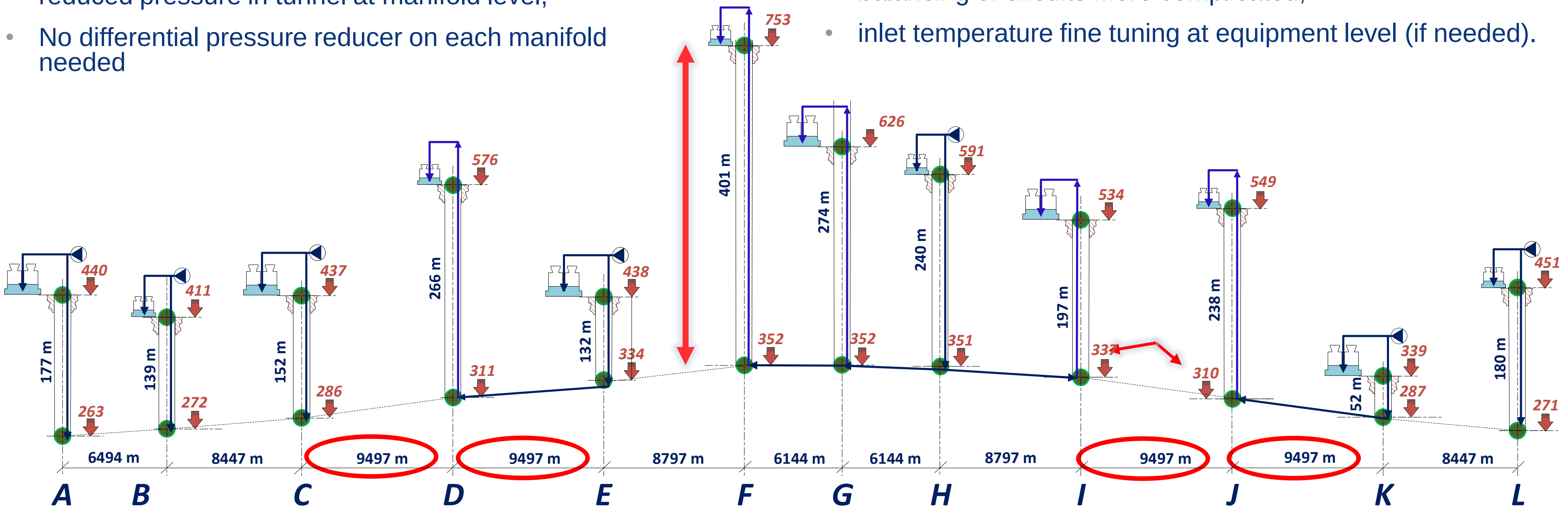
From: Weather Conditions in the Geneva Area, Doubek, EDMS 1714932 v 1.0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal CT	Maintenance	Maintenance	N_m+1	N_m+1	N_s	N_s	N_s	N_s	N_s	N_m+1	N_m+1	Maintenance
Back up CT	N_W+1	N_W+1	Maintenance	Maintenance	+1	+1	+1	+1	+1	Maintenance	Maintenance	N_W+1

Constraints due to heights and depths

- Underground depth Point F, 400 m, (as in FCC week 2016):
  - static pressure 40 bars
  - separate circuits between surface & underground.
- Highest Altitude variation in sector IJ, 27 m:
  - 2.7 bar, pressure (10 bar in FCC week 2016)
  - reduced pressure in tunnel at manifold level,
  - No differential pressure reducer on each manifold needed

- Maximum Sector length in CD, DE, IJ and JK 9.5 km (1 km less than in FCC week 2016) :
  - increase diameter to reduce pressure losses -> avoid use of booster pumps,
  - sectorization valves and connection to drain along the sector,
  - balancing of circuits more complicated,
  - inlet temperature fine tuning at equipment level (if needed).



Underground Hydraulic Cooling Power and Diameters

FCC-ee Point		Total underground	Cryogenics	Experiments	RF	Tunnel left	Tunnel right
A	P (MW)	15.5		0.5		7.3	7.3
	ND	*400*		*100*		*500*	*500*
C,K	P (MW)	21.0				9.9	11.1
	ND	*450*				*500*	*600*
D, J	P (MW)	23.0	1.8		21.2		
	ND	*450*	*150*		*500*		
E, I	P (MW)	21.4				11.1	10.3
	ND	*450*				*600*	*600*
G	P (MW)	14.7		0.5		7.1	7.1
	ND	*350*		*100*		*500*	*500*

FCC-hh Point	FCC-hh	Total underground	Cryogenics	Experiments	RF	Tunnel left	Tunnel right
A	P [MW]	5.6	1.5	2.7		0.7	0.7
	ND	*250*	*125*	*150*		*150*	*150*
B,L	P [MW]	2.0		2.0			
	ND	*200*		*200*			
C,K	P [MW]	6.0	2.9			1.4	1.7
	ND	*250*	*200*			*200*	*200*
E,I	P [MW]	5.8	2.9			1.6	1.3
	ND	*250*	*200*			*200*	*200*
G	P [MW]	5.5	1.5	2.7		0.65	0.65
	ND	*350*	*125*	*150*		*100*	*100*
H	P [MW]	6.0	1.5		4.5		
	ND	*250*	*125*		*250*		

Chilled Water requirements

FCC-ee Point	Cooling power [kW]	Flow rate [m³/h]	Number of chillers	Cooling power/ chiller [kW]
A	1780	255	3	900
B,L	1500	215	3	800
C,K	1850	115	3	900
D,J	5760	827	4	2000
E,I	1860	267	3	1000
F	1490	214	3	800
G	3460	497	4	1200
H	1490	214	3	800

FCC-hh Point	Cooling power [kW]	Flow rate [m³/h]	Number of chillers	Cooling power/ chiller [kW]
A	4410	633	5	1100
B,L	2340	336	3	1200
C,K	4150	595	5	1100
D,J	1220	175	2	1200
E,I	4130	593	5	1100
F	1140	163	2	1200
G	4360	626	5	1100
H	1480	212	3	750

CONCLUSIONS

- The ventilation system for the FCC has evolved to respond to the new requirements in terms of safety
- A first approach to the ventilation system for the HE-LHC has been designed, including a strategy in case of smoke in one compartment
- Cooling needs for FCC-ee and FCC-hh have been reviewed and a proposal for the cooling tower complex has been shown, it includes:
  - The needs in number and size of cells
  - Proposals to reduce water consumption and blowdown
  - Proposals for maintenance in case of long running periods
- Main parameters of Chilled and Demineralised water circuits have been described

THANK YOU FOR YOUR ATTENTION