FCC

Future Circular Collider

Technical Infrastructure

Ventilation update for FCC

I. Martin Melero (EN/CV)

FCC Week 2025

Outline

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- 1. Update on thermal toads
  - 1.1. Primary circuit heat loads
  - 1.2. Chillers
  - 1.3. Chilled water loads
- 2. Update on integration
  - 2.1. Technical Points: B, F
  - 2.2. RF Points: H, L
  - 2.3. Exp. Points: A, D, G, J
- 3. Update on tunnel concept
  - 3.1. General parameters
  - 3.2. Semi-transverse
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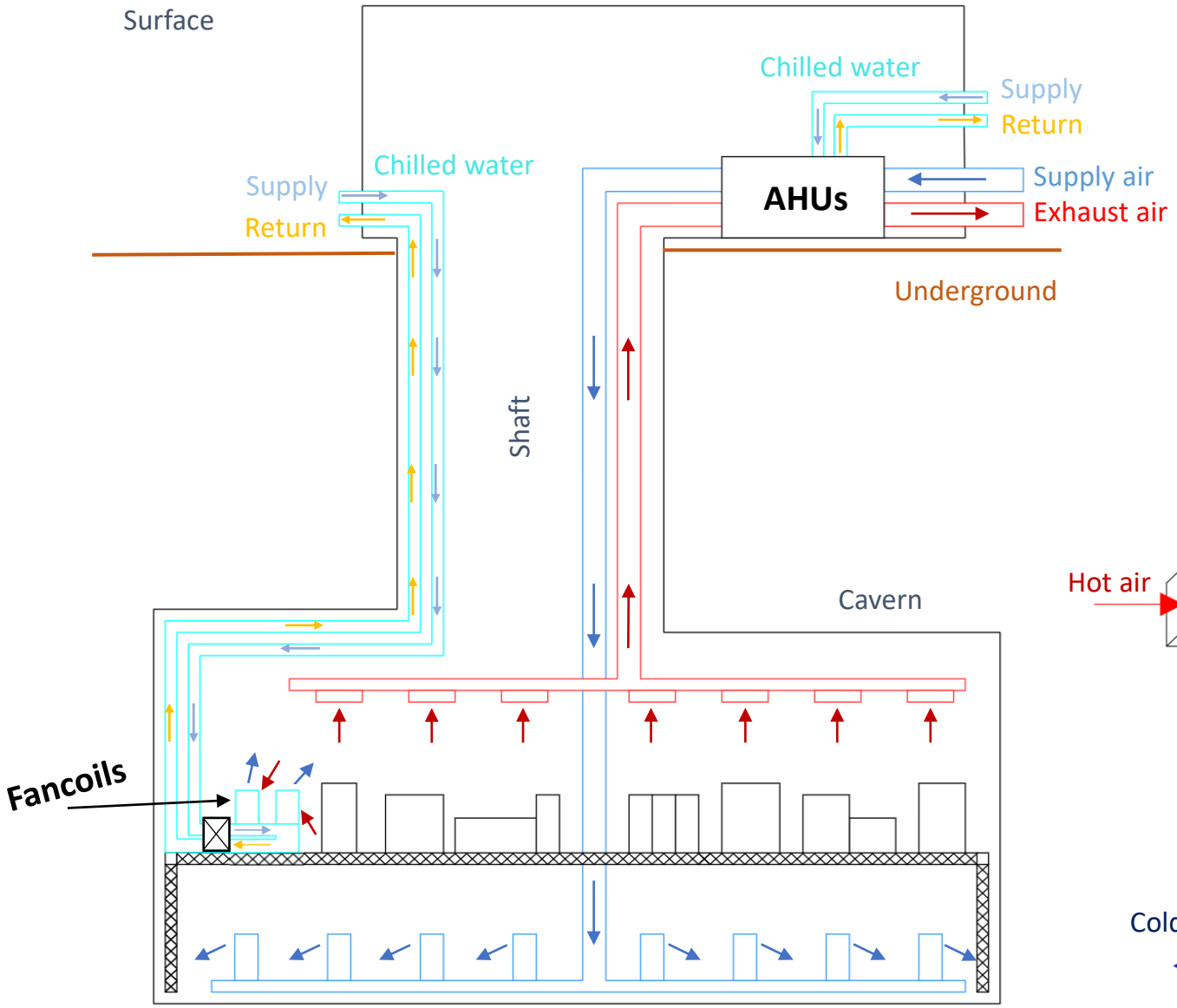
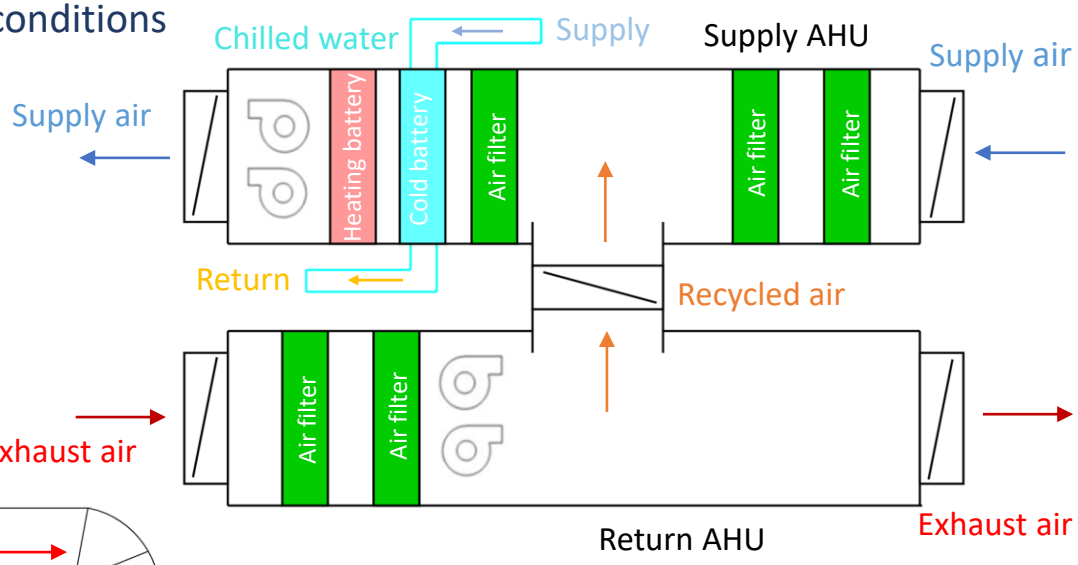
  - 3.4. Adaptation Run / Access → Emergency
  - 3.5. Fire heat effects
  - 3.6. Pressure differences
  - 3.7. Degraded modes
- 4. Next steps

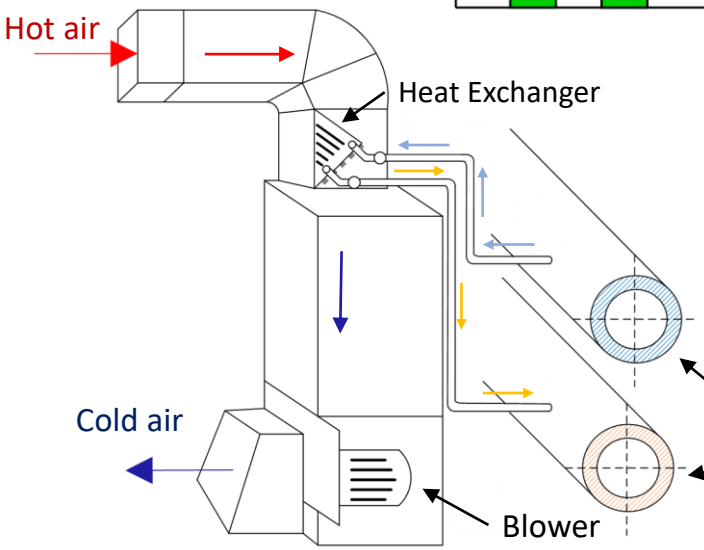
0. Definitions



AHUs

- Treatment of the air to *temperature* and *humidity* conditions



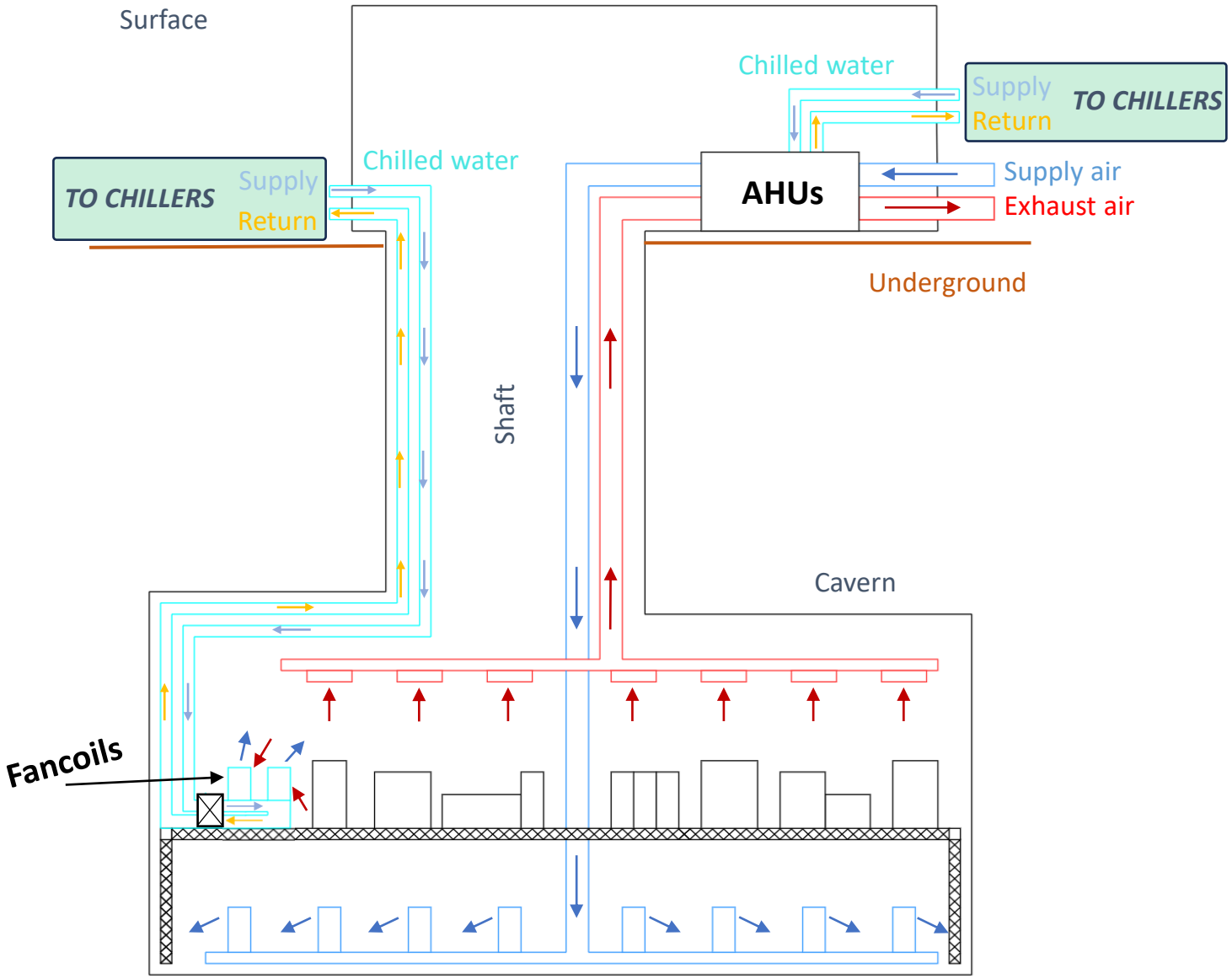


Fancoils

- Recirculation of air through coils to locally adjust *temperature* conditions

Chilled water supply and return

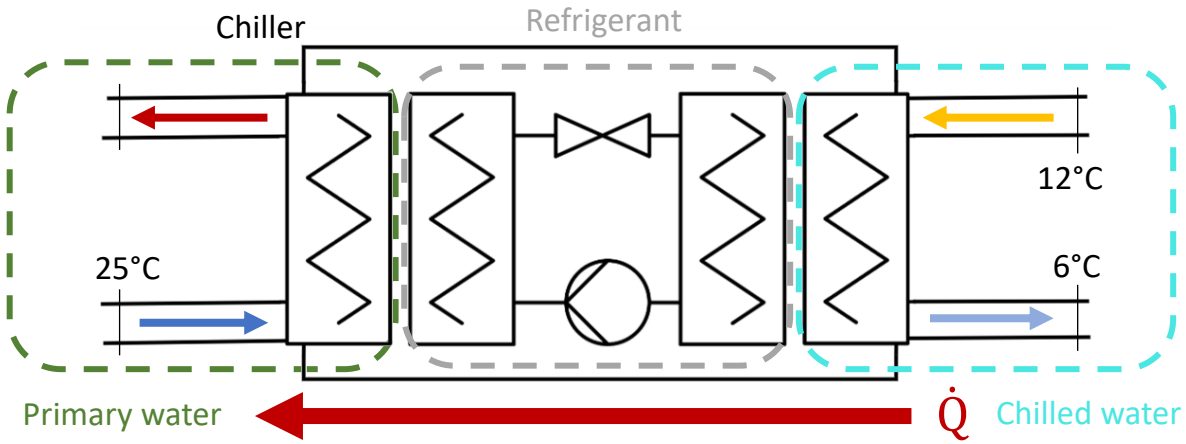
1. Update on thermal loads



1. Update on thermal loads *Primary circuit heat loads*

Heat loads (MW) at Cooling Towers, FCC-ee ttbar

Point	Cryogenics	Experiment	General Services	Power converters RF	Chilled Water	Underground	TOTAL
A	0.35	0.50	2.00		5.87	42.56	**51**
B			2.00		5.18	1.05	**8**
D	0.35	0.50	2.00		5.84	42.56	**51**
F			2.00		5.18	1.05	**8**
G	0.35	0.50	2.00		5.87	42.56	**51**
H	34.00		2.00	4.50	11.24	48.95	**100**
J	0.35	0.50	2.00		5.84	42.56	**51**
L	10.00		2.00	0.07	5.71	2.74	**20**



Ventilation cooling requirements in Primary Water Circuit

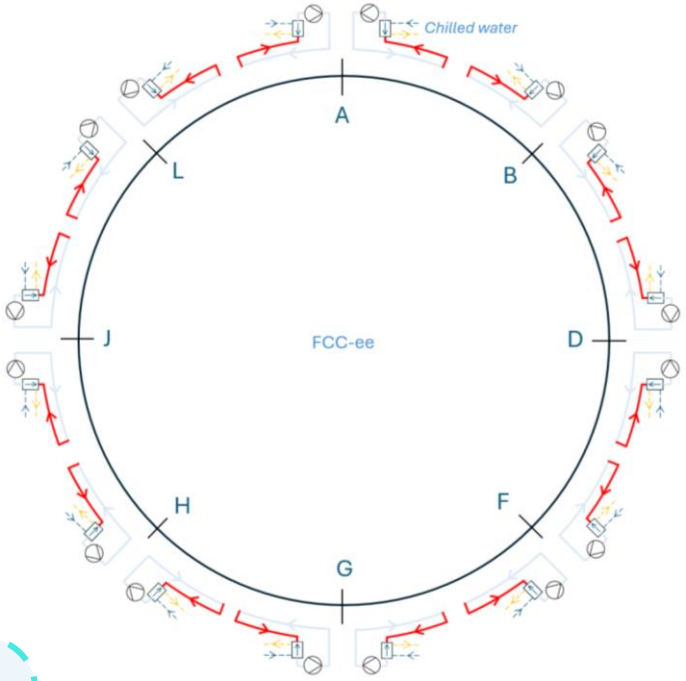
More info:
I. Martin Melero @ Session TIWG 5

1. Update on thermal loads *Chillers*

Chillers, FCC-ee ttbar

Point	Cooling power (kW)	Flow rate (m^3/h)	Number of chillers	Cooling power / chiller (kW)	TOTAL (kW)
A	4,895	703	6	1,000	**6,000**
B	4,322	620	6	900	**5,400**
D	4,875	700	6	1,000	**6,000**
F	4,322	620	6	900	**5,400**
G	4,895	703	6	1,000	**6,000**
H	9,367	1345	7	1,800	**12,600**
J	4,875	700	6	1,000	**6,000**
L	4,757	683	6	1,000	**6,000**

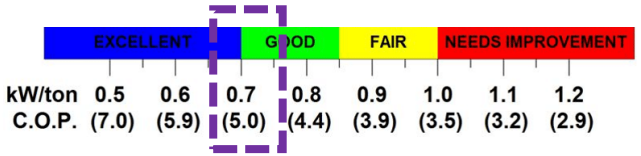
Chilled water requirements

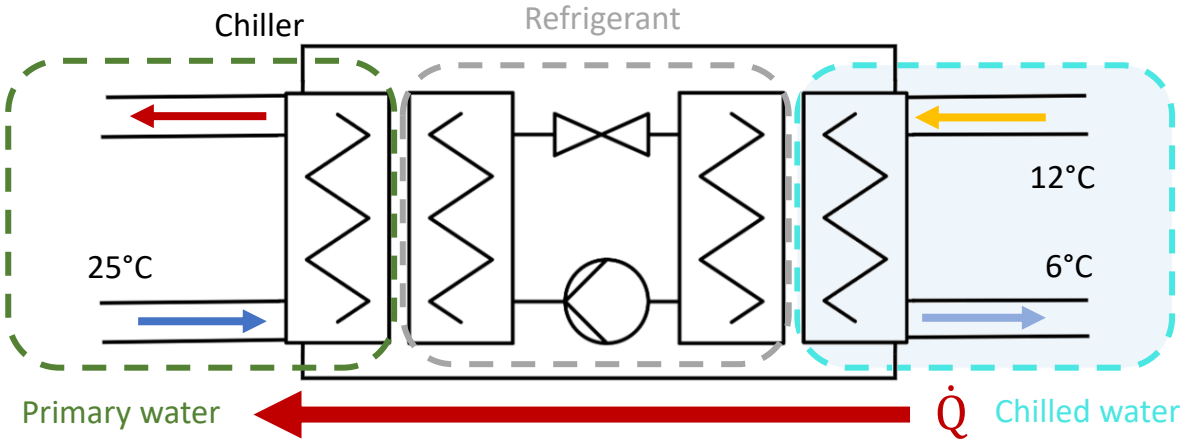


Increase in chillers due to cable load Tunnel

Primary water requirements in Table p. 5

COP ≈ 5





1. Update on thermal loads *Chilled water loads*

1. Surface heat loads to chilled water (kW)							
POINT	Cryogenics	Power Converters	General Services	Experimental Areas	Shaft Pressurisation	Fresh Air for Underground Areas	TOTAL TO CHILLED WATER
A	13		500	50	300	150	**1013**
B			500		150	50	**700**
D	13		500	40	300	150	**1003**
F			500		150	50	**700**
G	13		500	50	300	150	**1013**
H	1,400*	2,250*	500		150	150	**800**
J	13		500	40	300	150	**1003**
L	402*	35*	500		150	150	**800**

Chilled water load = 1. Surface + 2. Underground + 3. Sector

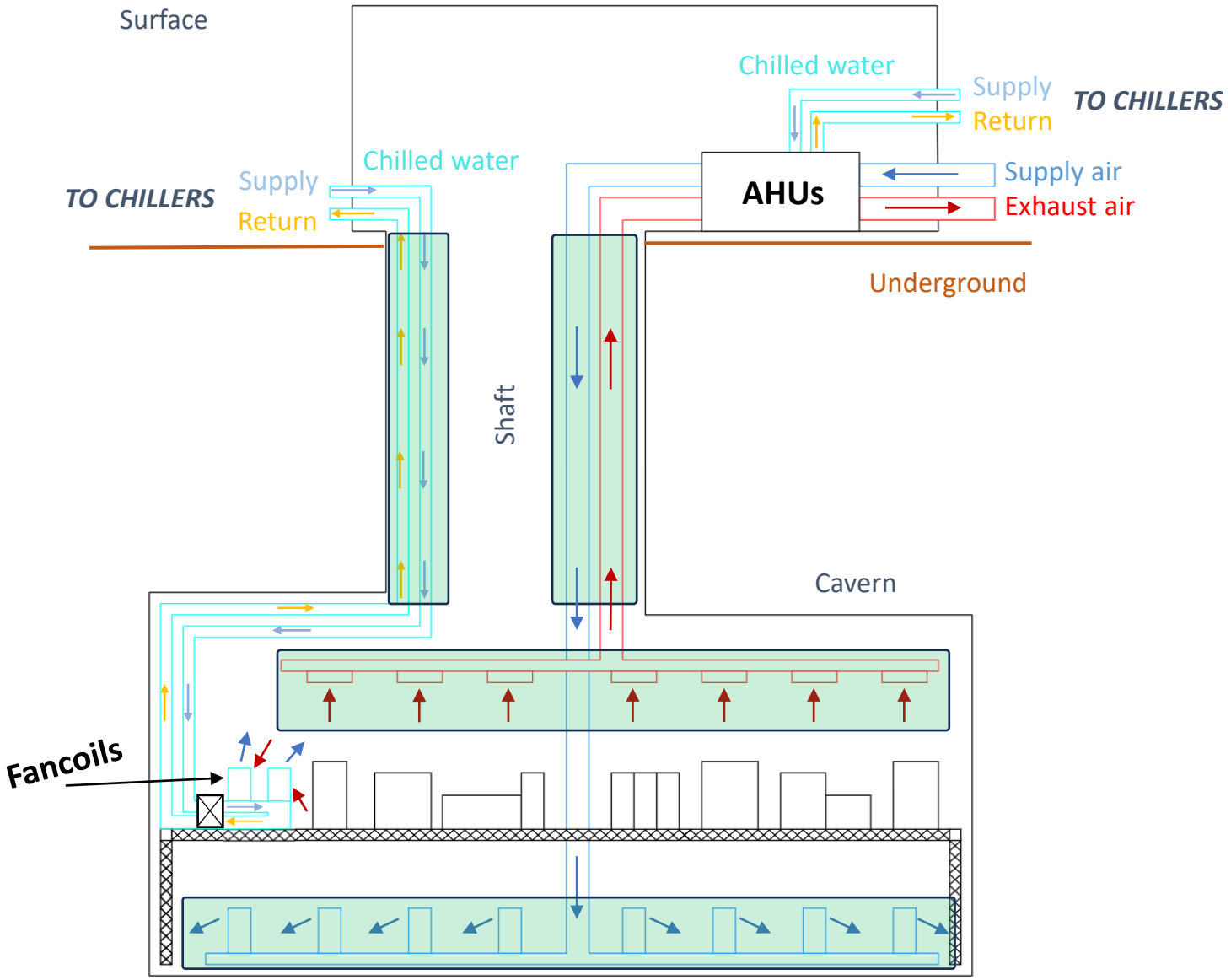
*Extracted without chilled water → Option: free cooling

3. Sector heat loads to chilled water (kW)				
Magnets	Cables	Synchrotron radiation absorbers	Alcoves	TOTAL PER SECTOR
352	2,500	250	300	**3,402**

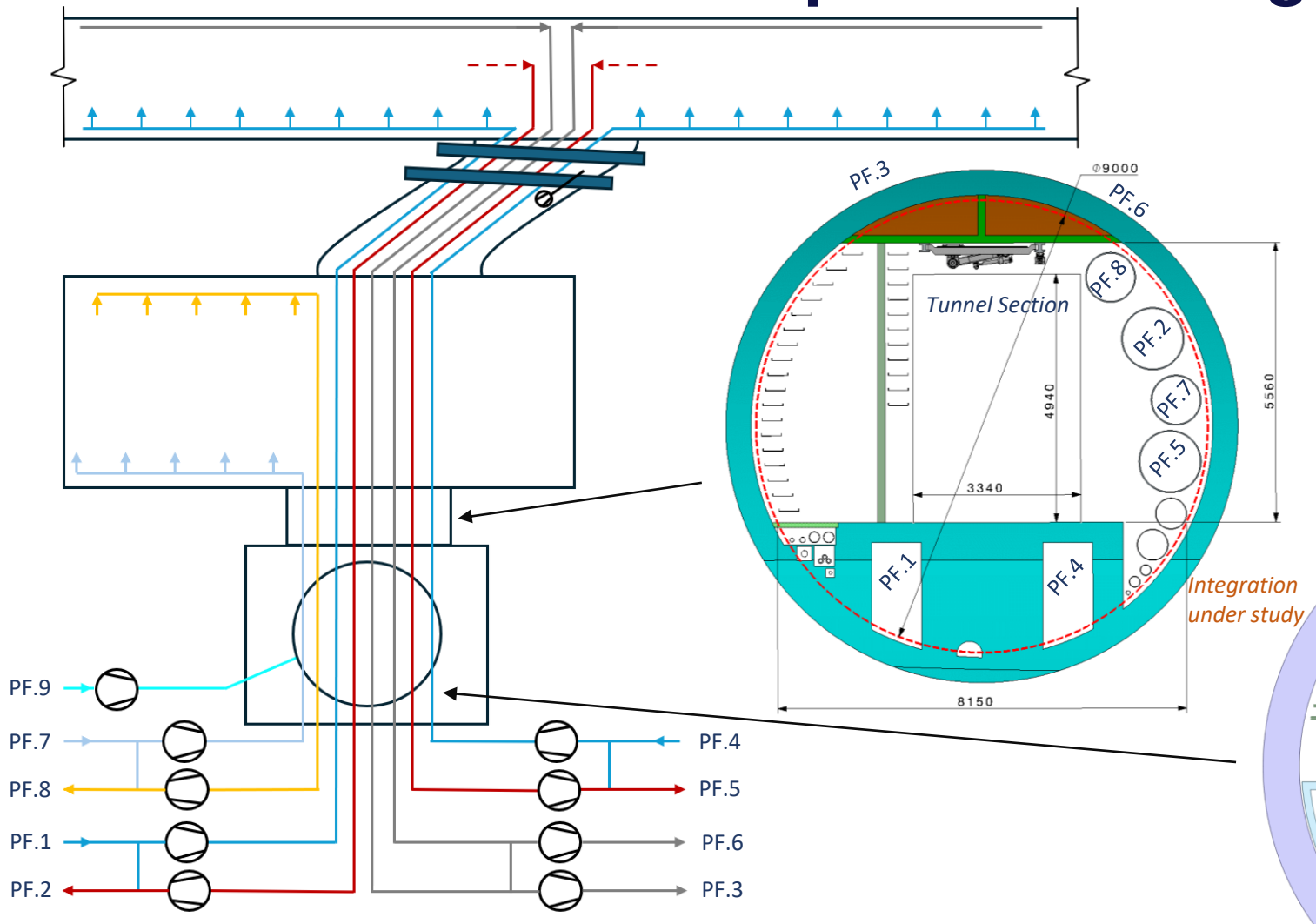
Scenario for 7 alcoves

2. Underground heat loads to chilled water (kW)						
POINT	Cryogenics	RF	Experimental Areas	Power Converters	Ventilation UW	TOTAL
A	10		50	220	200	**480**
B				220		**220**
D	10		40	220	200	**470**
F				220		**220**
G	10		50	220	200	**480**
H	145	4,600		220	200	**5,165**
J	10		40	220	200	**470**
L	60	75		220	200	**555**

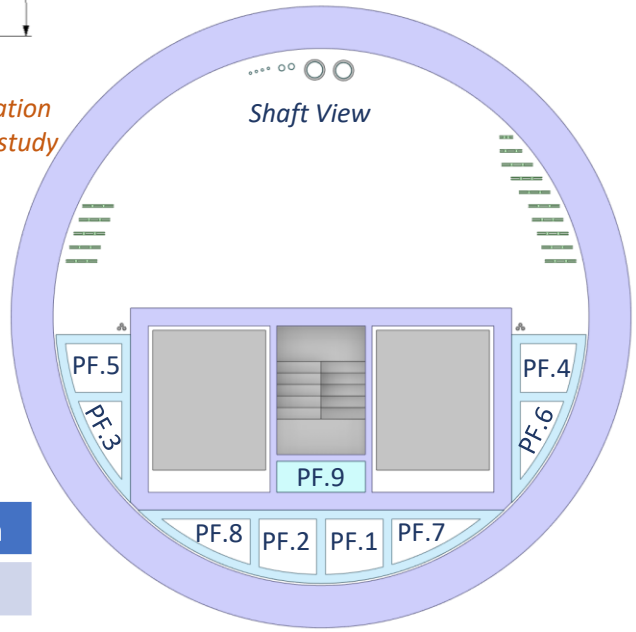
2. Update on integration

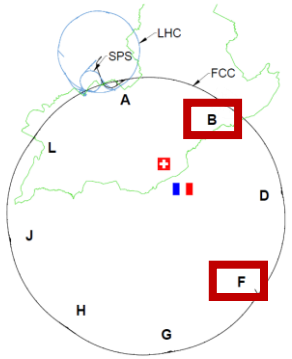


2. Update on integration *Technical Points: B, F*



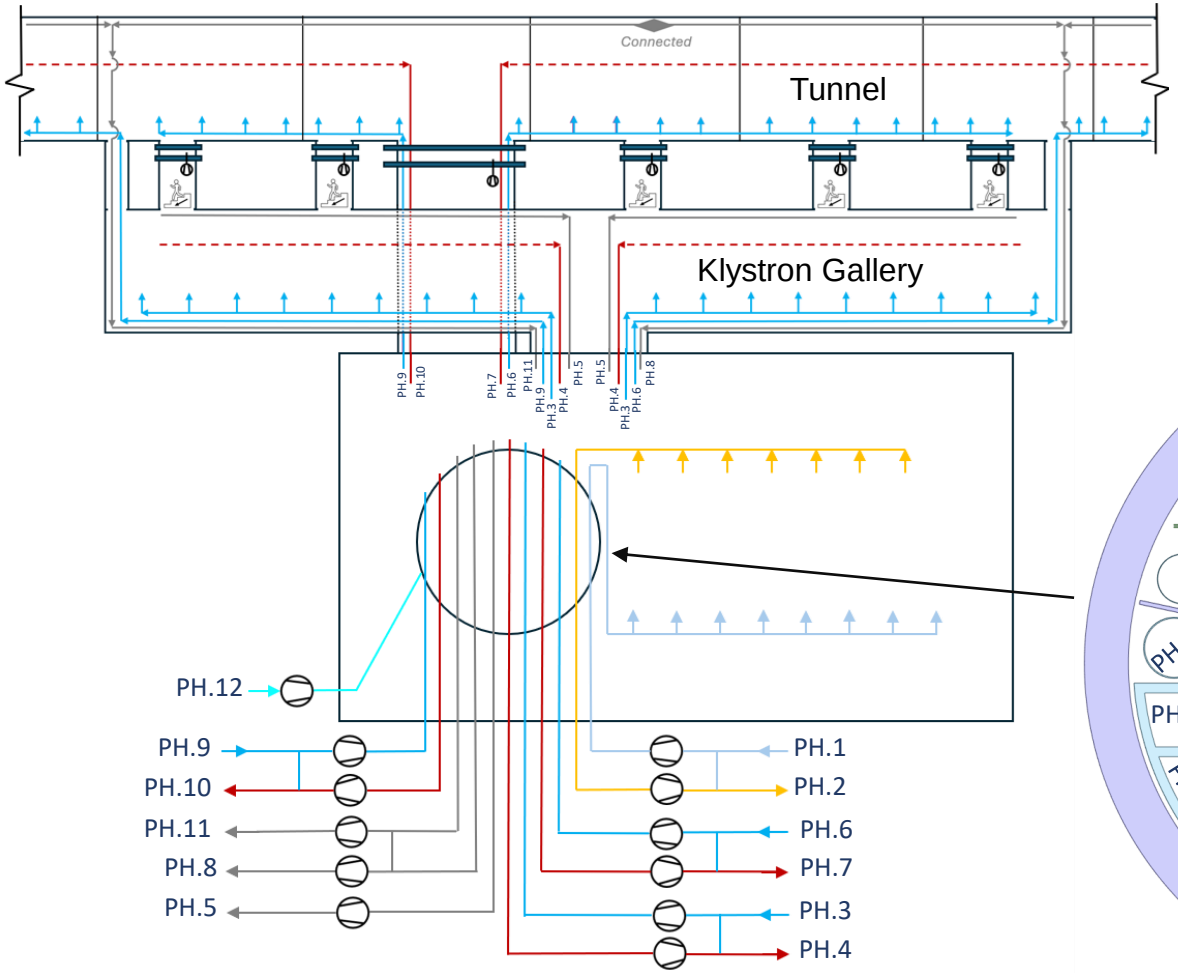
Reference	Duct Function	Size
PF.1	Ventilation Tunnel Supply 1	1.2 m
PF.2	Ventilation Tunnel Extract 1	1.2 m
PF.3	Ventilation Emergency Extract 1	1.2 m
PF.4	Ventilation Tunnel Supply 2	1.2 m
PF.5	Ventilation Tunnel Extract 2	1.2 m
PF.6	Ventilation Emergency Extract 2	1.2 m
PF.7	Ventilation Service Cavern Supply	1.1 m
PF.8	Ventilation Service Cavern Extract	1.1 m
PF.9	Shaft Pressurisation	1.2 m



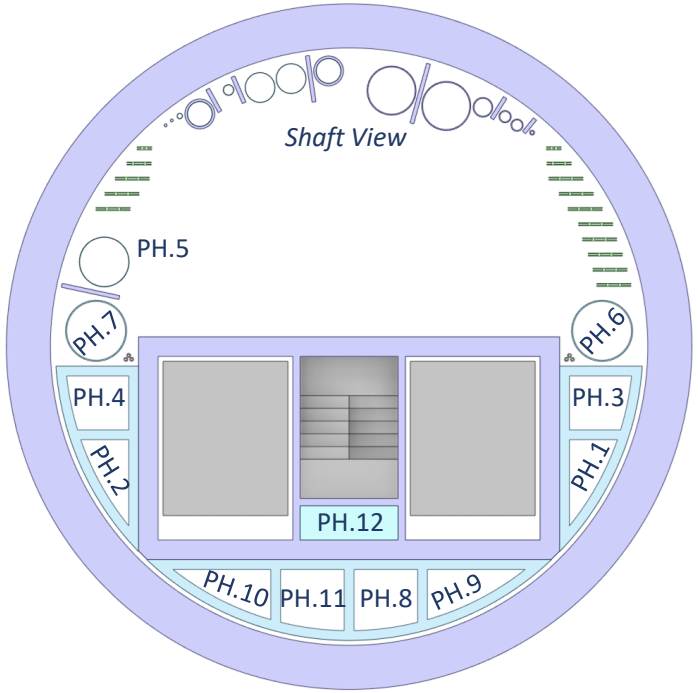


Technical Areas in B, F	Air Supply	Extraction	Emergency extraction
Access Mode	Ventilation Service Cavern: 40,000 m³/h	40,000 m³/h	40,000 m³/h

2. Update on integration *RF Points: H, L*

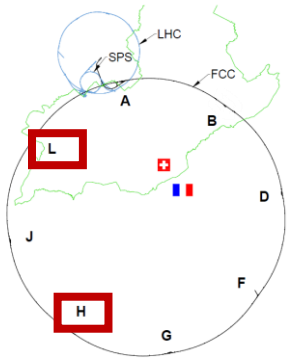


Integration under study

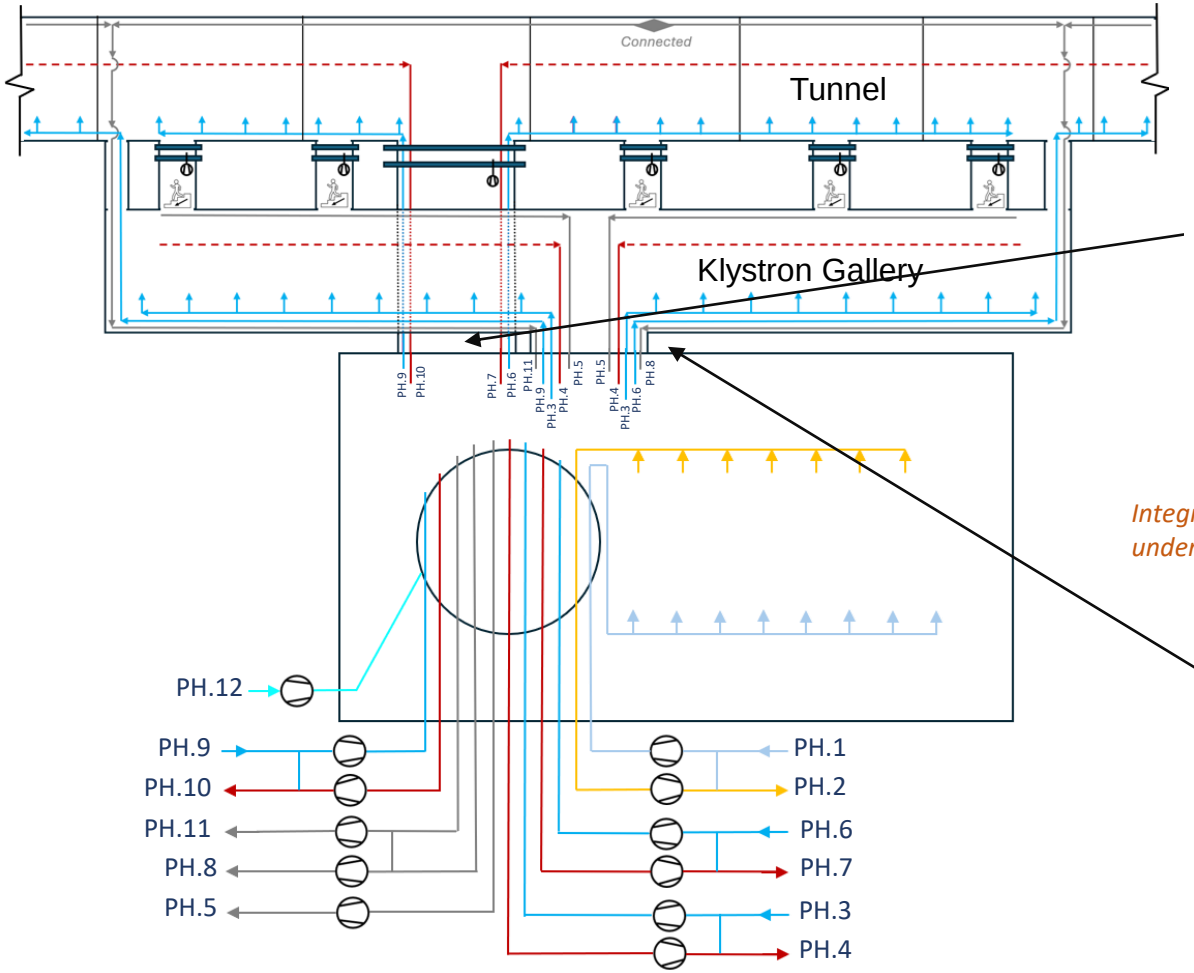


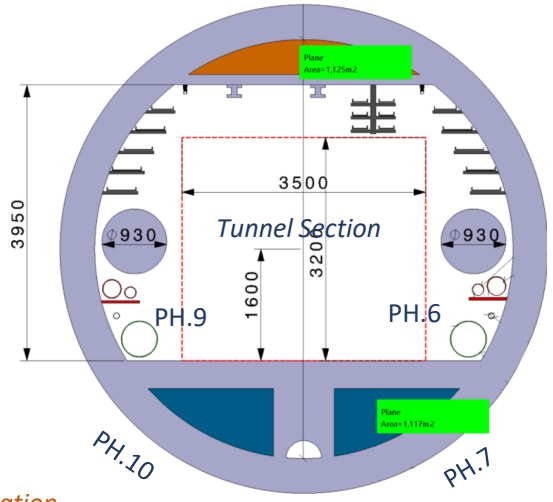
Reference	Duct Function	Size
PH.1	Ventilation Service Cavern Supply	1.1 m
PH.2	Ventilation Service Cavern Extract	1.1 m
PH.3	Ventilation Klystron Gallery Supply	1 m
PH.4	Ventilation Klystron Gallery Extract	1 m
PH.5	Ventilation Klystron Gallery Emergency	1 m
PH.6	Ventilation Tunnel Supply 1	1.2 m
PH.7	Ventilation Tunnel Extract 1	1.2 m
PH.8	Ventilation Emergency Extract 1	1.2 m
PH.9	Ventilation Tunnel Supply 2	1.2 m
PH.10	Ventilation Tunnel Extract 2	1.2 m
PH.11	Ventilation Emergency Extract 2	1.2 m
PH.12	Shaft Pressurisation	1.2 m

Technical Areas in H,L	Air Supply	Extraction	Emergency extraction
Access Mode	Ventilation Service Cavern: 40,000 m^3/h	40,000 m^3/h	40,000 m^3/h

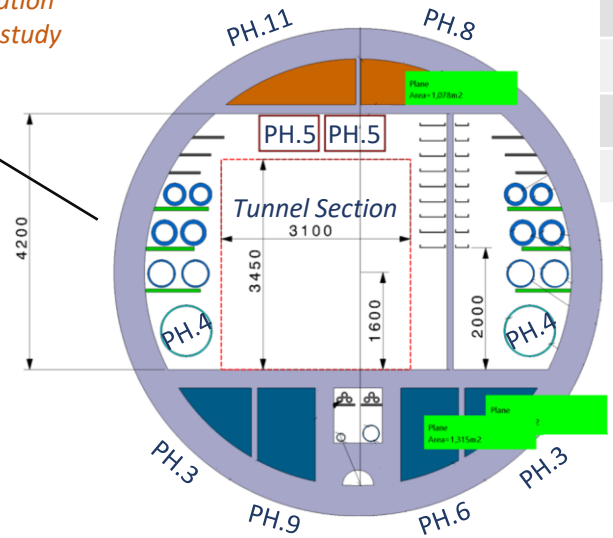


2. Update on integration *RF Points: H, L*



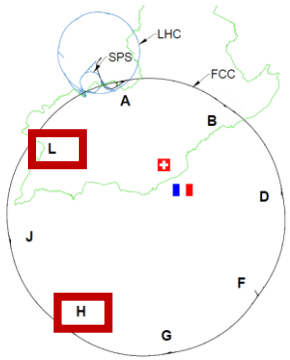


Integration under study

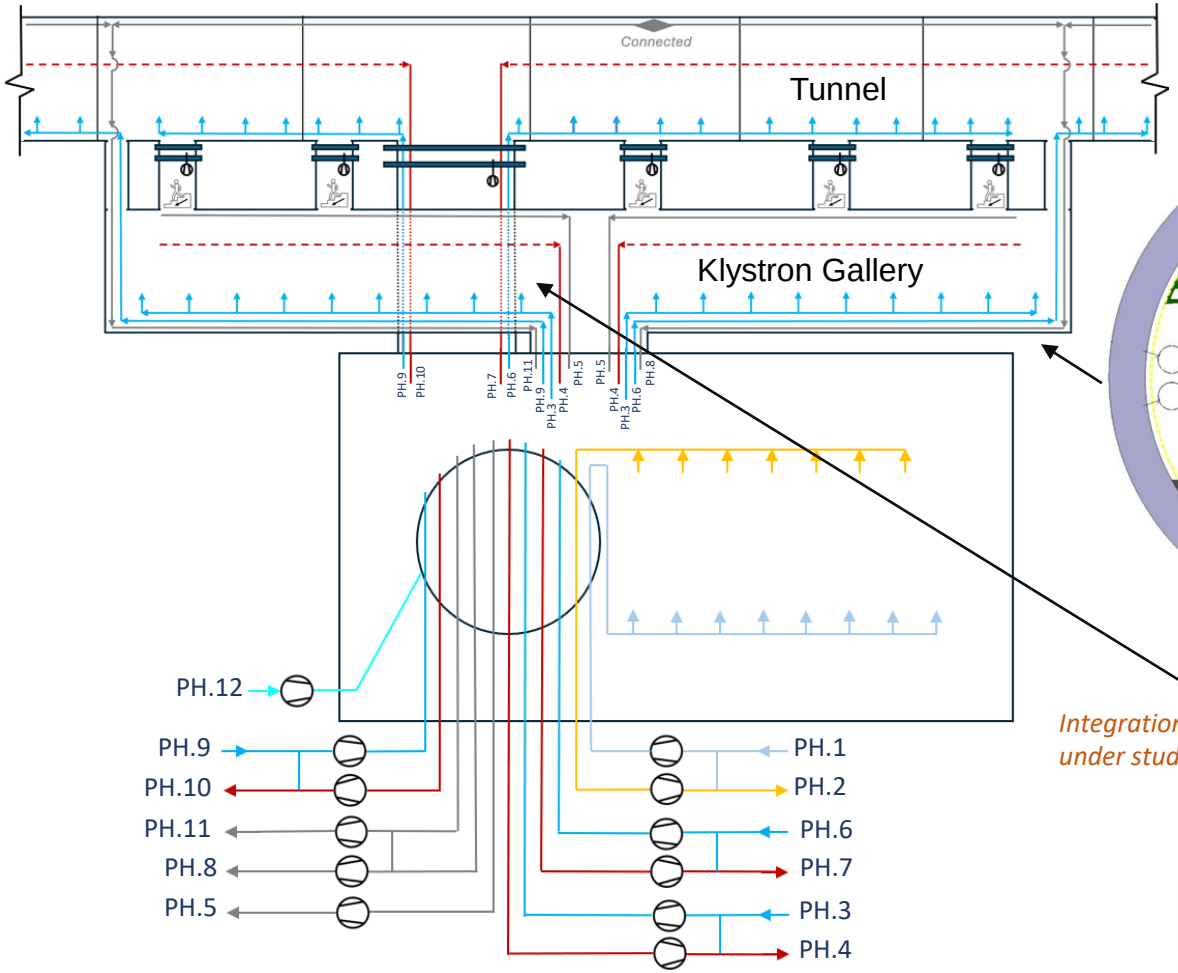


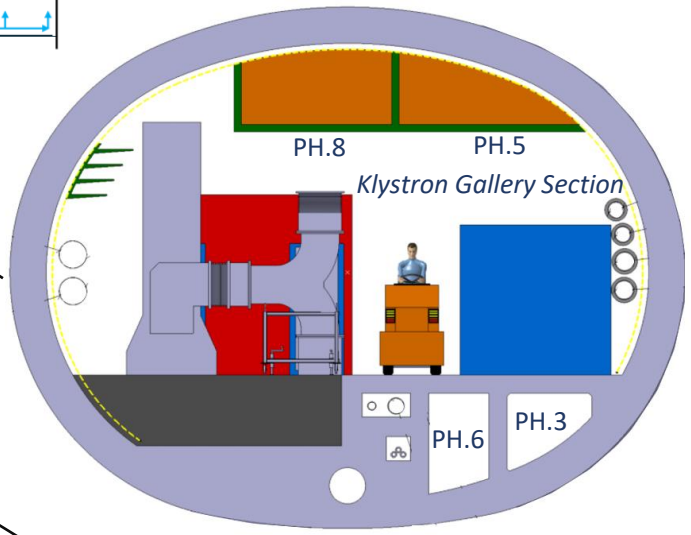
Reference	Duct Function	Size
PH.1	Ventilation Service Cavern Supply	1.1 m
PH.2	Ventilation Service Cavern Extract	1.1 m
PH.3	Ventilation Klystron Gallery Supply	1 m
PH.4	Ventilation Klystron Gallery Extract	1 m
PH.5	Ventilation Klystron Gallery Emergency	1 m
PH.6	Ventilation Tunnel Supply 1	1.2 m
PH.7	Ventilation Tunnel Extract 1	1.2 m
PH.8	Ventilation Emergency Extract 1	1.2 m
PH.9	Ventilation Tunnel Supply 2	1.2 m
PH.10	Ventilation Tunnel Extract 2	1.2 m
PH.11	Ventilation Emergency Extract 2	1.2 m
PH.12	Shaft Pressurisation	1.2 m

Technical Areas in H,L	Air Supply	Extraction	Emergency extraction
Access Mode	Ventilation Service Cavern: 40,000 m³/h	40,000 m³/h	40,000 m³/h

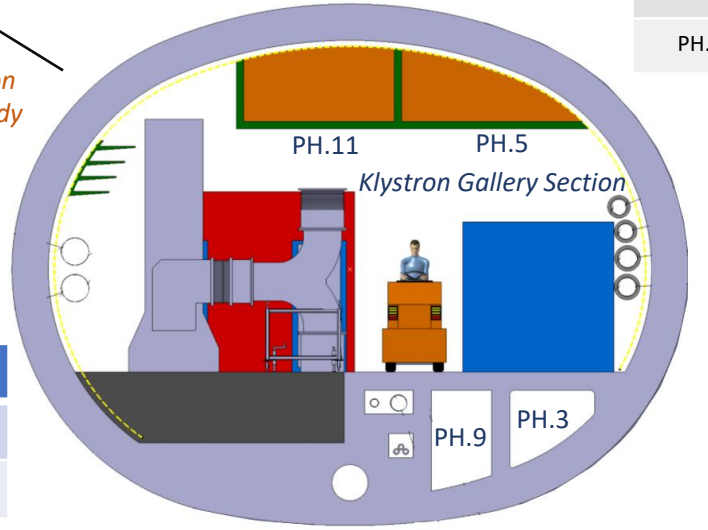


2. Update on integration *RF Points: H, L*



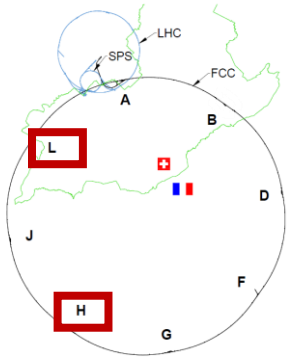


Integration under study



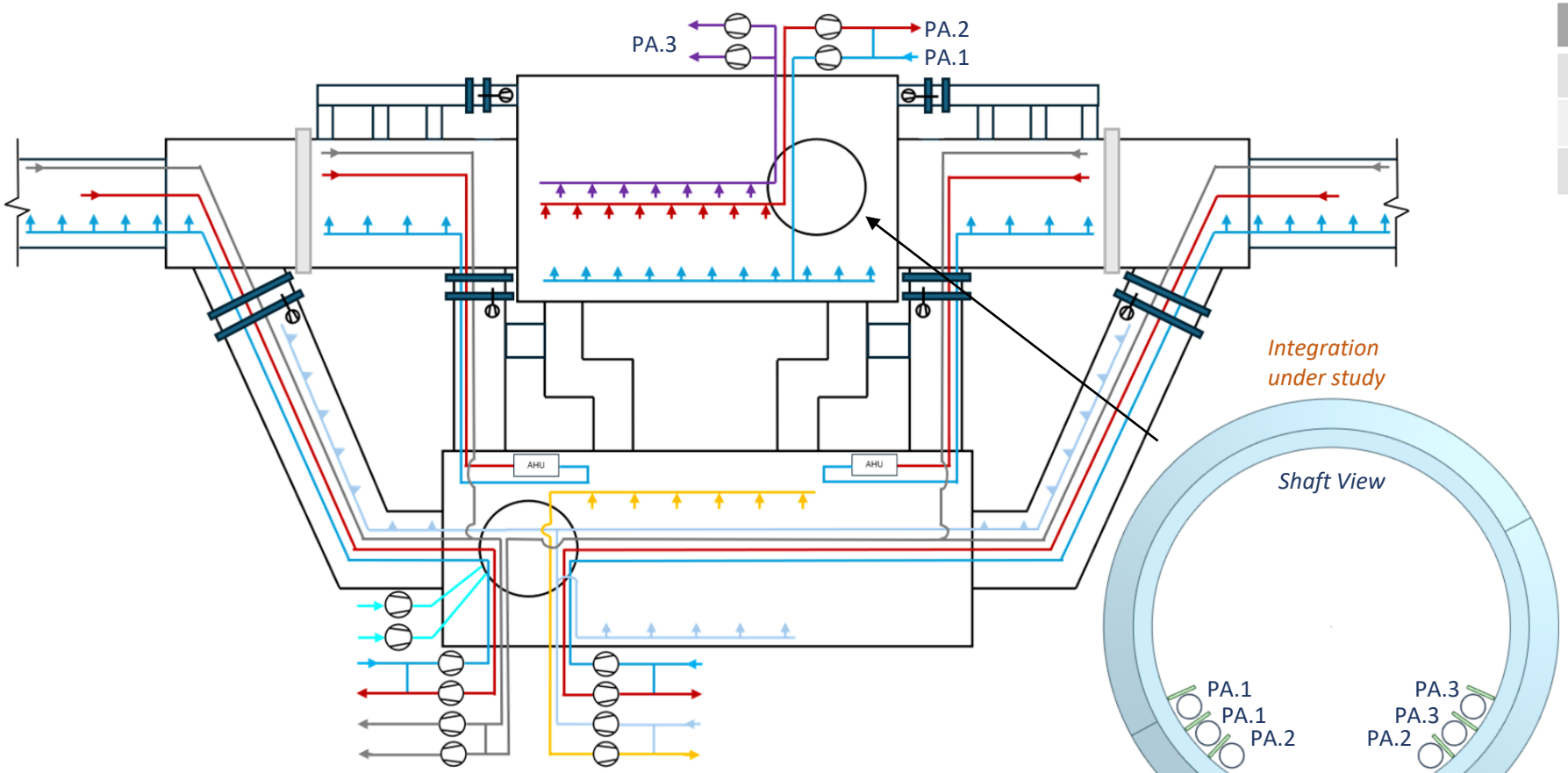
Reference	Duct Function	Size
PH.1	Ventilation Service Cavern Supply	1.1 m
PH.2	Ventilation Service Cavern Extract	1.1 m
PH.3	Ventilation Klystron Gallery Supply	1 m
PH.4	Ventilation Klystron Gallery Extract	1 m
PH.5	Ventilation Klystron Gallery Emergency	1 m
PH.6	Ventilation Tunnel Supply 1	1.2 m
PH.7	Ventilation Tunnel Extract 1	1.2 m
PH.8	Ventilation Emergency Extract 1	1.2 m
PH.9	Ventilation Tunnel Supply 2	1.2 m
PH.10	Ventilation Tunnel Extract 2	1.2 m
PH.11	Ventilation Emergency Extract 2	1.2 m
PH.12	Shaft Pressurisation	1.2 m

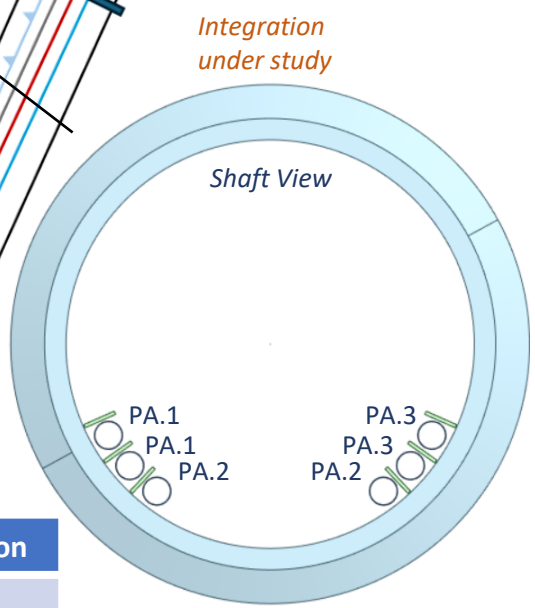
RF Areas in H, L	Air Supply	Extraction	Emergency extraction
Run & Access Mode	30.000 m^3/h	30.000 m^3/h	OFF
Emergency conditions	< 30.000 m^3/h	< 30.000 m^3/h	< 30.000 m^3/h



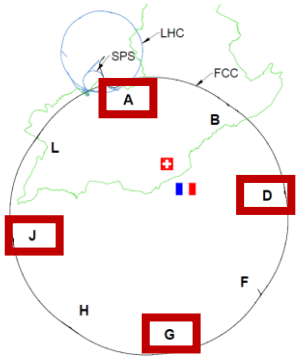
2. Update on integration *Exp. Points: A, D, G, J*

Reference	Duct Function	Size
PA.1	Ventilation Experimental Cavern, Supply	1.2 m
PA.2	Ventilation Experimental Cavern, Extract	1.2 m
PA.3	Ventilation Experimental Cavern, Gas Extract	1.2 m

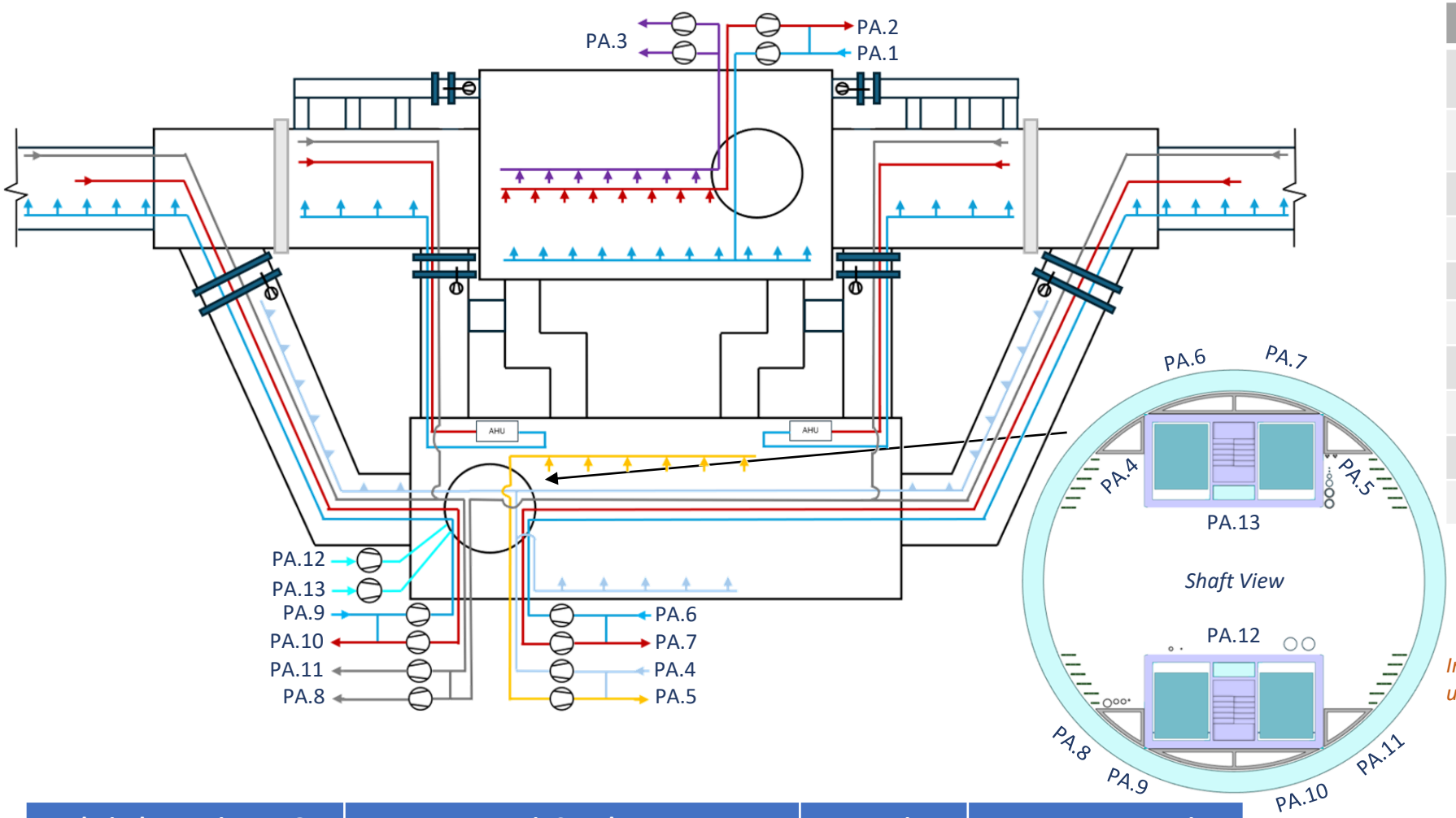




Exp. Areas in A,D,G,J	Air Supply	Regular Extraction	Gas Extraction
Run & Access Mode	50.000 – 70.000 m^3/h	50.000 – 70.000 m^3/h	OFF
Flushing Mode	50.000 – 70.000 m^3/h	50.000 – 70.000 m^3/h	OFF
Fire Emergency	Up to 70.000 m^3/h	Up to 70.000 m^3/h	OFF
Gas Emergency	20.000 m^3/h	OFF	20.000 m^3/h



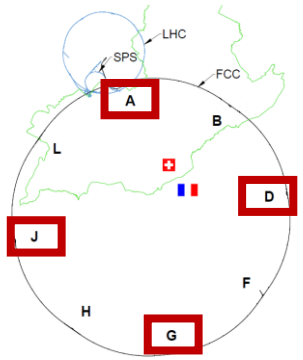
2. Update on integration *Exp. Points: A, D, G, J*



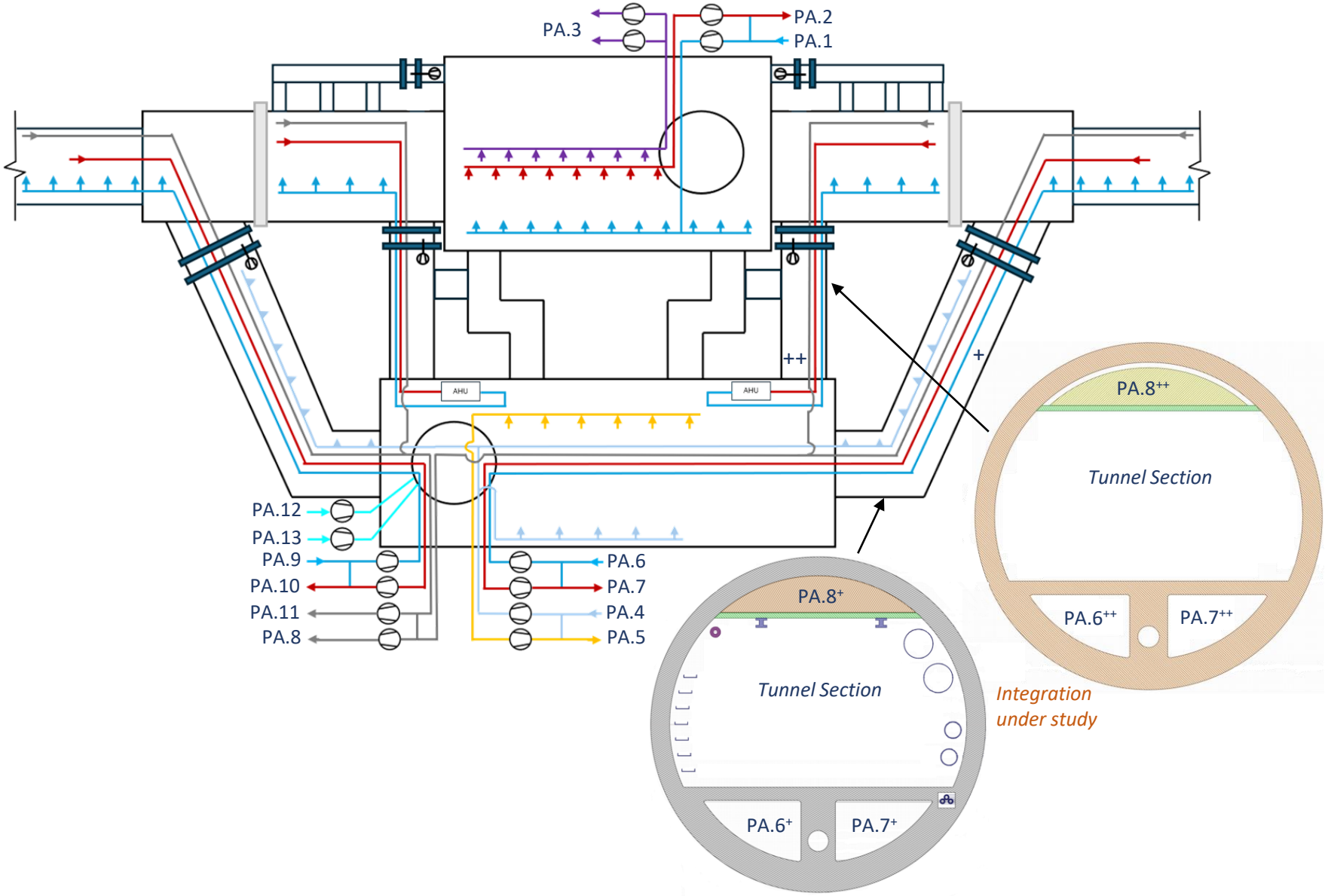
Reference	Duct Function	Size
PA.4	Ventilation Service Cavern Supply + Fresh Air for UAs Supply	1.3 m
PA.5	Ventilation Service Cavern Extract + Fresh Air for UAs Extract	1.3 m
PA.6	Ventilation Tunnel Supply 1	1.2 m
PA.7	Ventilation Tunnel Extract 1	1.2 m
PA.8	Ventilation Emergency Extract 1	1.2 m
PA.9	Ventilation Tunnel Supply 2	1.2 m
PA.10	Ventilation Tunnel Extract 2	1.2 m
PA.11	Ventilation Emergency Extract 2	1.2 m
PA.12	Shaft Pressurisation 1	1.2 m
PA.13	Shaft Pressurisation 2	1.2 m

Integration under study

Technical Areas in A,D,G,J	Air Supply	Extraction	Emergency extraction
Run & Access Mode	Fresh air UAs: 20,000 m³/h Ventilation Service Cavern: 40,000 m³/h	60,000 m³/h	60,000 m³/h

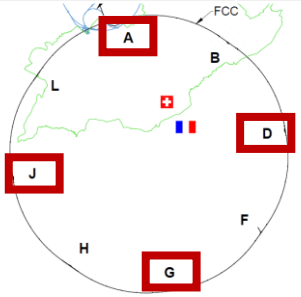


2. Update on integration *Exp. Points: A, D, G, J*

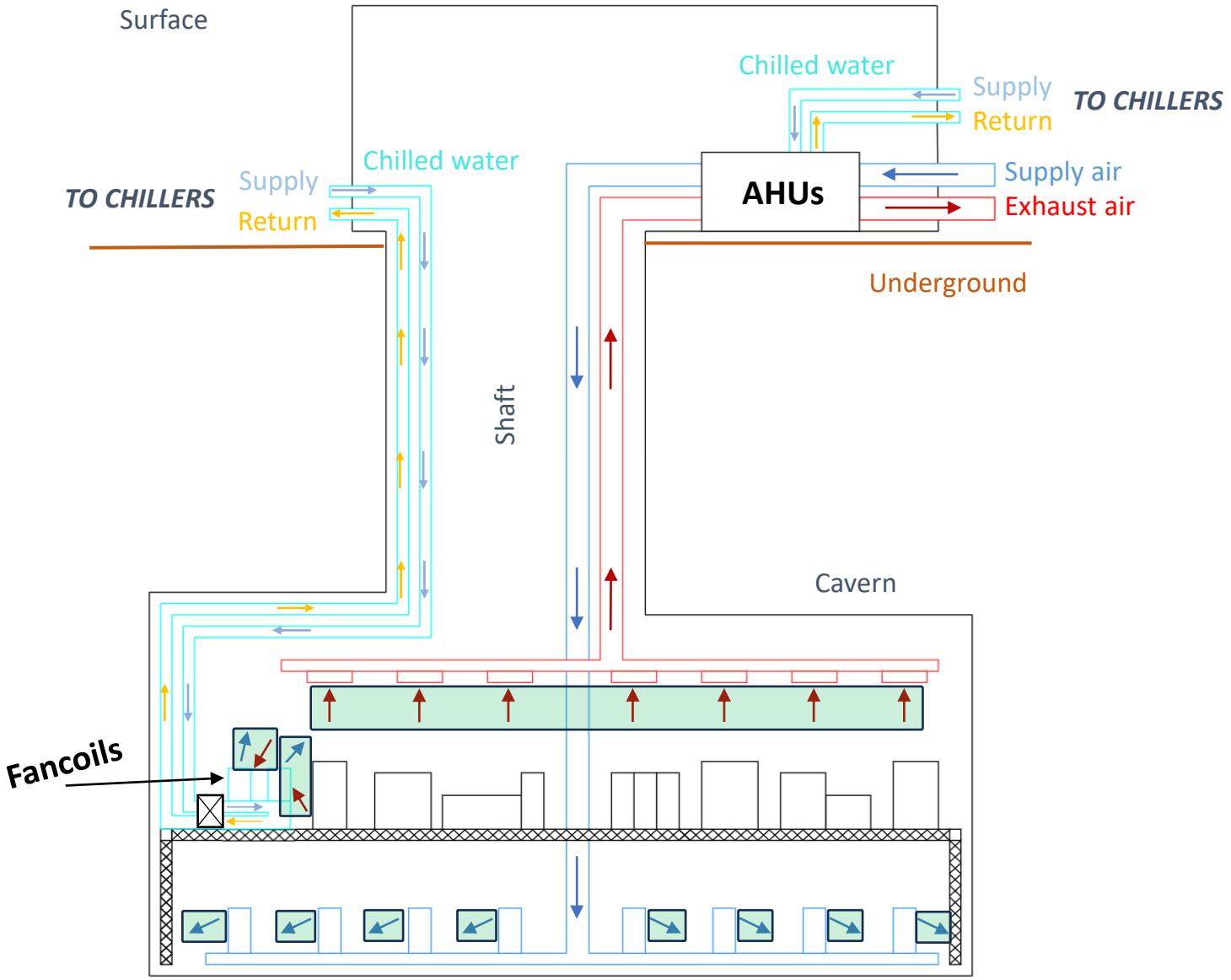


Reference	Duct Function	Size
PA.1	Ventilation Experimental Cavern, Supply	1.2 m
PA.2	Ventilation Experimental Cavern, Extract	1.2 m
PA.3	Ventilation Experimental Cavern, Gas Extract	1.2 m

Reference	Duct Function	Size
PA.4	Ventilation Service Cavern Supply + Fresh Air for UAs Supply	1.3 m
PA.5	Ventilation Service Cavern Extract + Fresh Air for UAs Extract	1.3 m
PA.6	Ventilation Tunnel Supply 1	1.2 m
PA.7	Ventilation Tunnel Extract 1	1.2 m
PA.8	Ventilation Emergency Extract 1	1.2 m
PA.9	Ventilation Tunnel Supply 2	1.2 m
PA.10	Ventilation Tunnel Extract 2	1.2 m
PA.11	Ventilation Emergency Extract 2	1.2 m
PA.12	Shaft Pressurisation 1	1.2 m
PA.13	Shaft Pressurisation 2	1.2 m



3. Update on tunnel concept



3. Update on tunnel concept

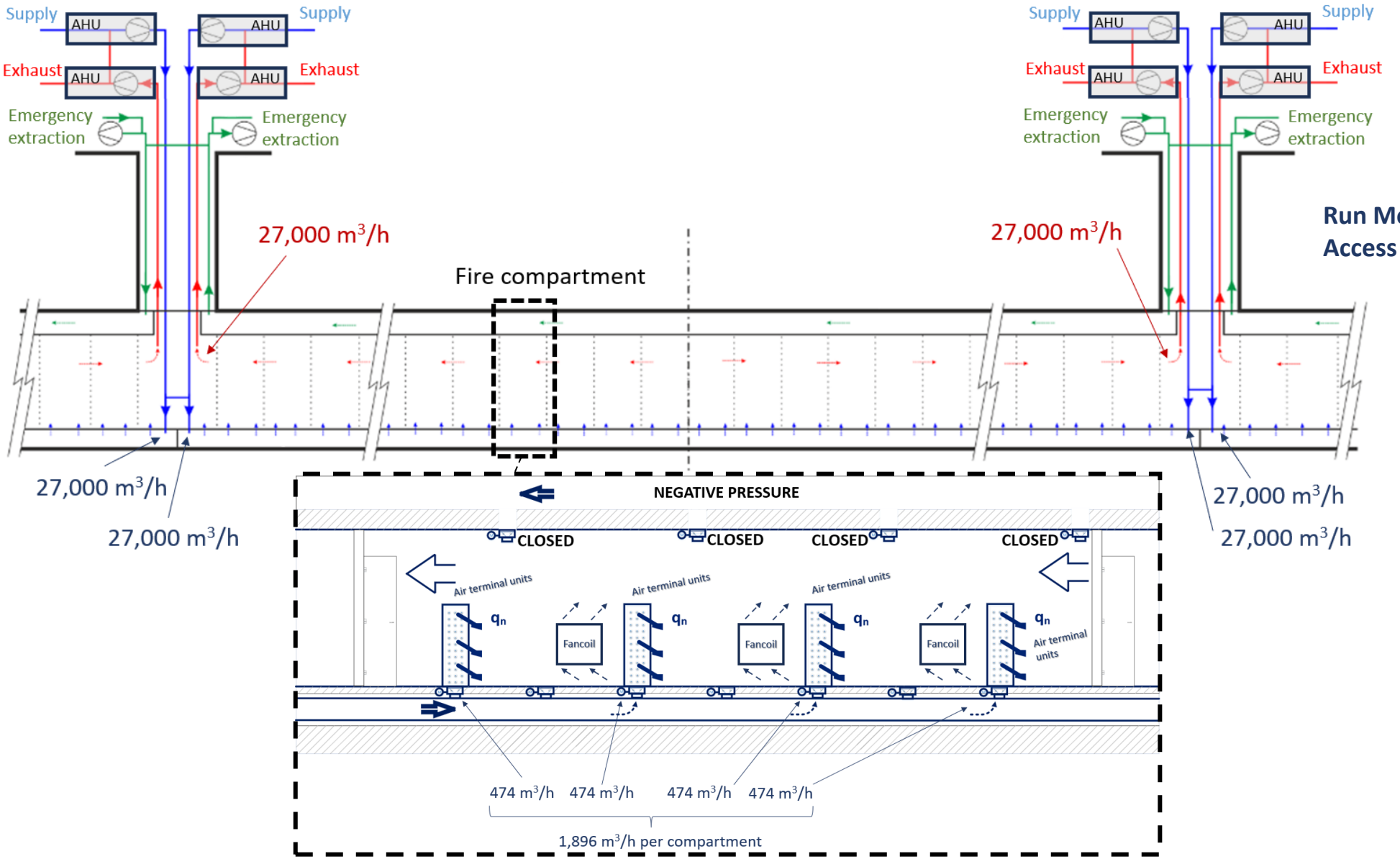
General parameters

General Input data	
Cross section area	15.2 m^2
Sector length	11,396 m
Max. Temperature (running conditions)	32ºC (to be confirmed)
Max. dew point Temperature	12ºC (to be confirmed

Compartment Input data	
Number of Compartments	29
Compartment length	400 m
Volume Compartment	6,080 m^3

Ventilation parameters	
Normal operation air flow per sector	2 x 27,000 m^3/h
Flushing air flow (longitudinal) per sector	100,000 m^3/h
Air supply points per compartment	4
Air flow per supply point (normal operation)	474 m^3/h
Time to complete air renewal (flushing)	1.7 h
Maximum air speed (normal operation – flushing)	0.5 m/s – 1.8 m/s
Cooling capacity in normal operation for ΔT = 15 K per sector	271 kW

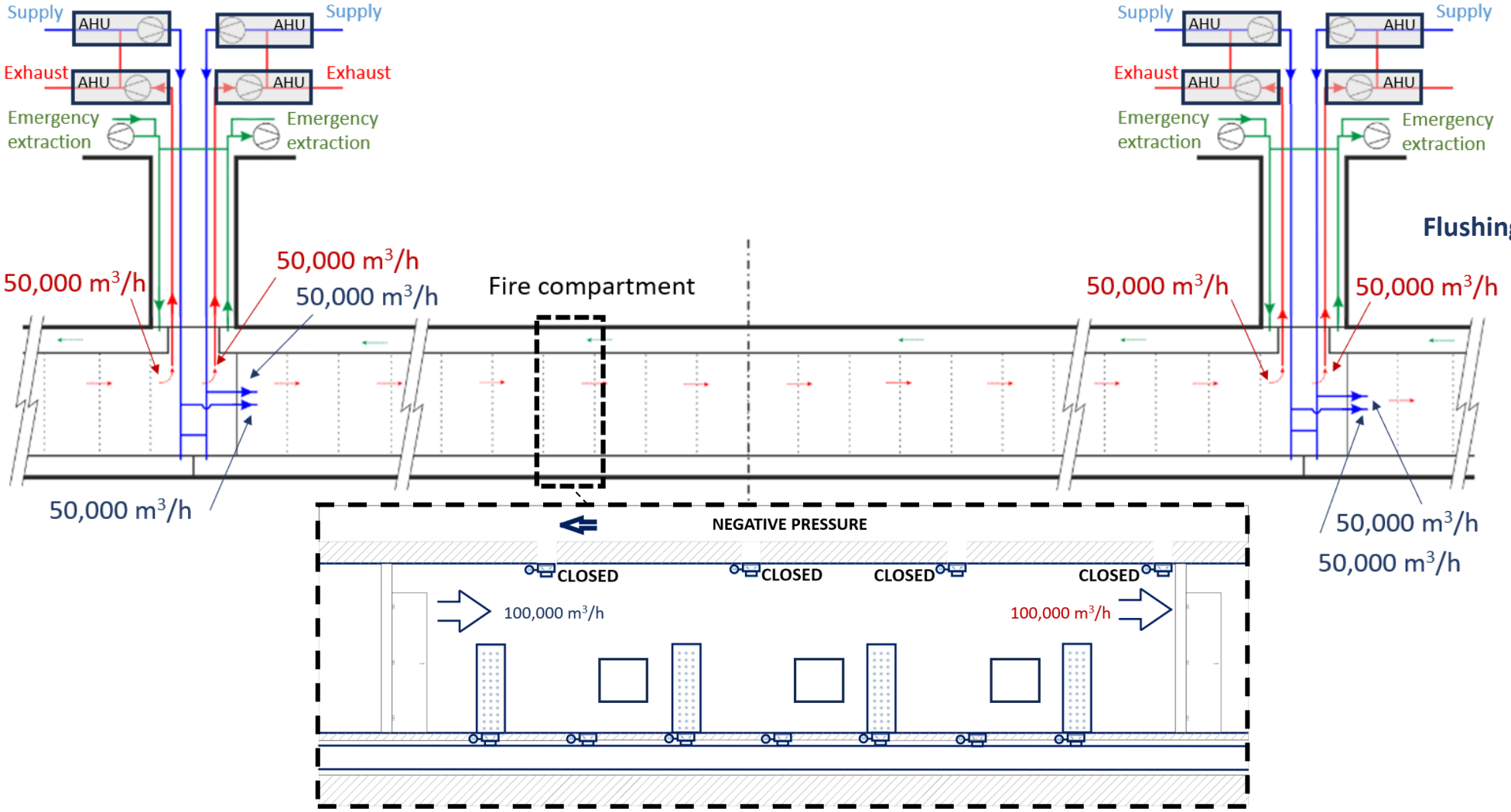
3. Update on tunnel concept *Semi-transverse*



Run Mode → Machine is in operation

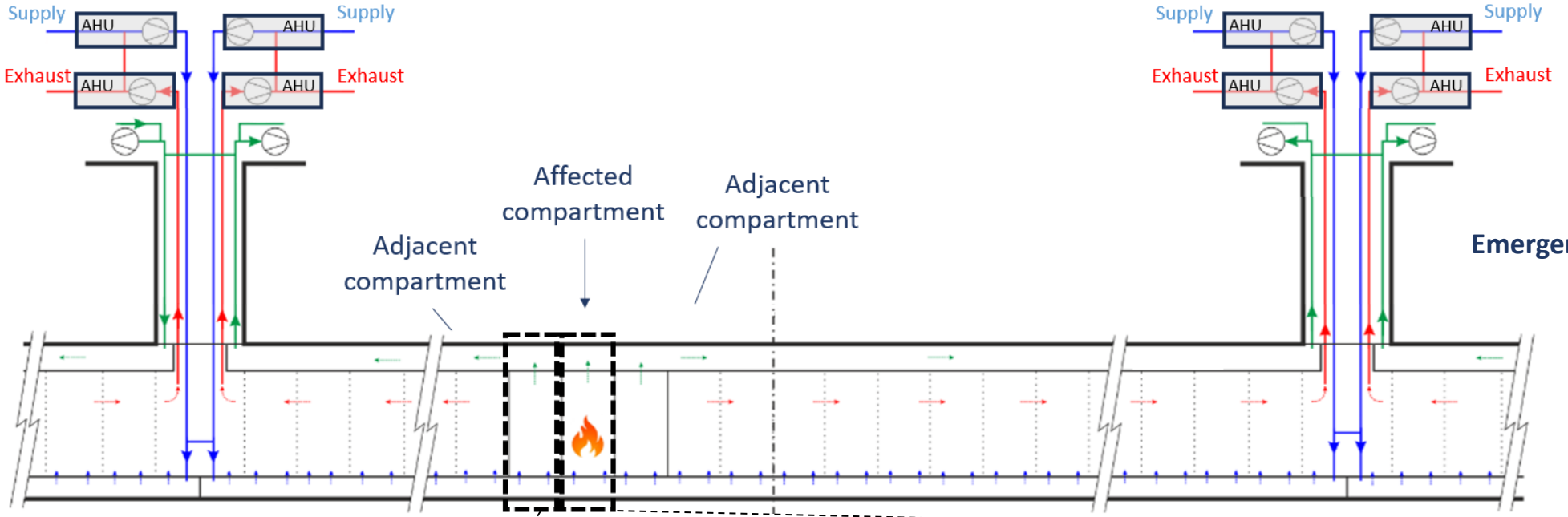
Access Modes → Maintenance / works are done in the tunnel

3. Update on tunnel concept *Semi-transverse*

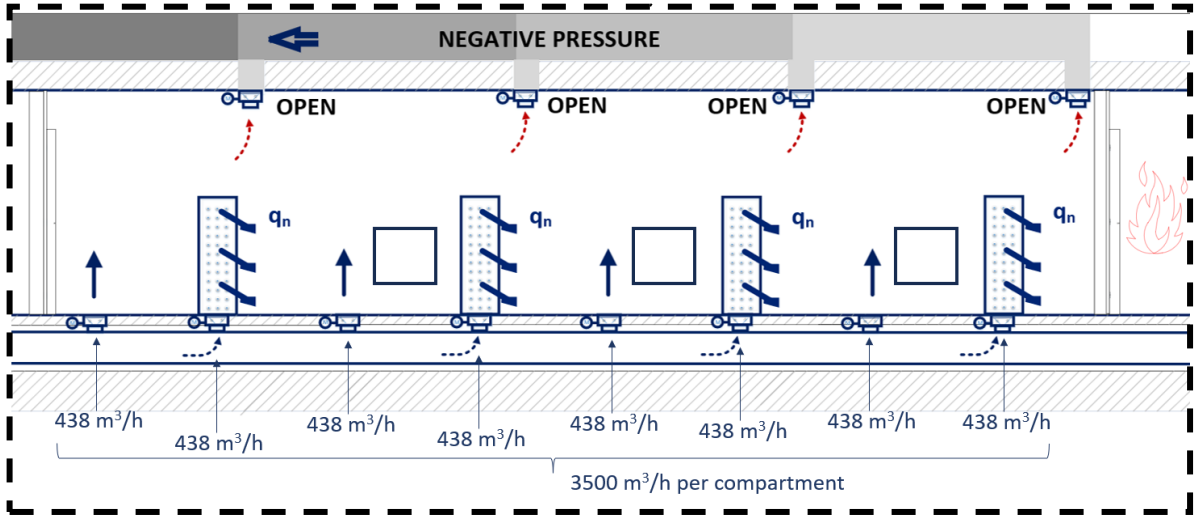


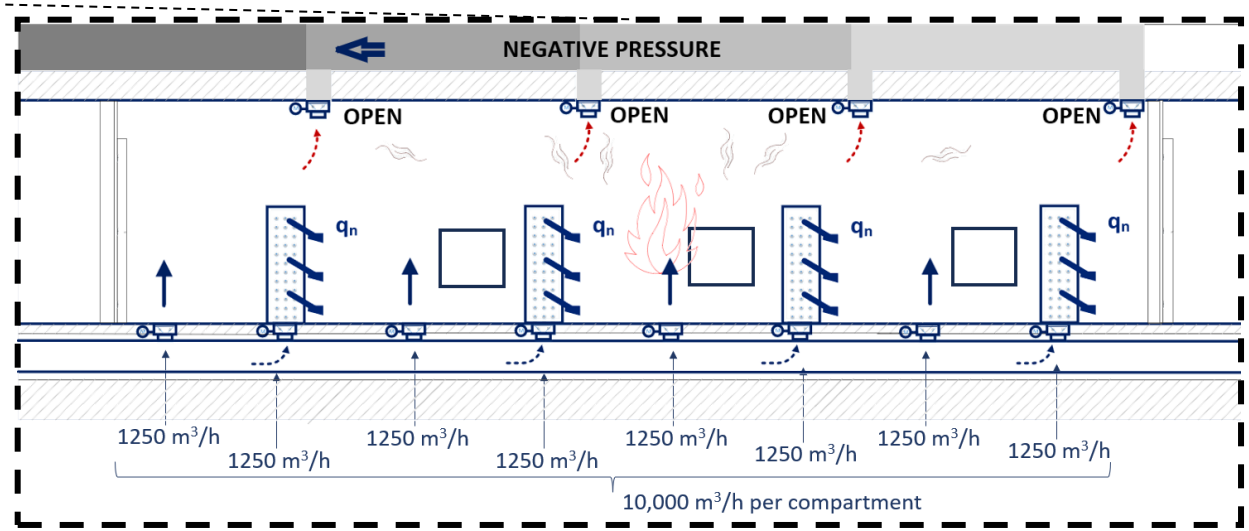
Flushing Mode → Full air renewal between Access and Run Modes

3. Update on tunnel concept *Semi-transverse*

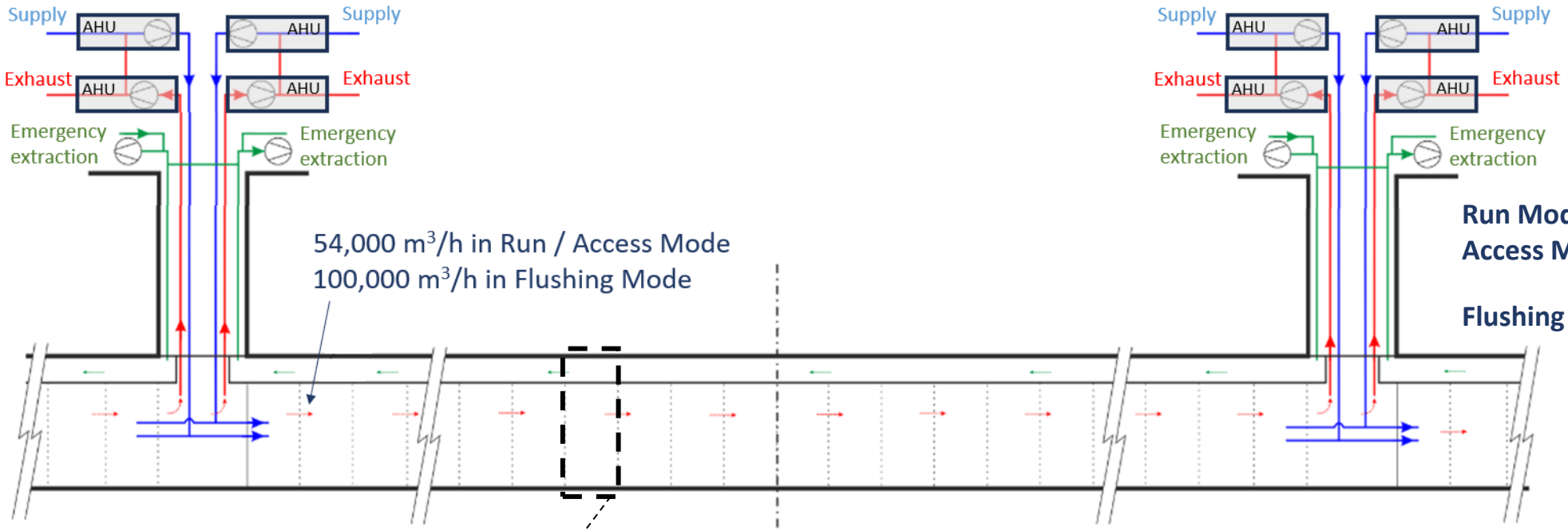


Emergency Mode → Smoke & fire or helium leak scenario





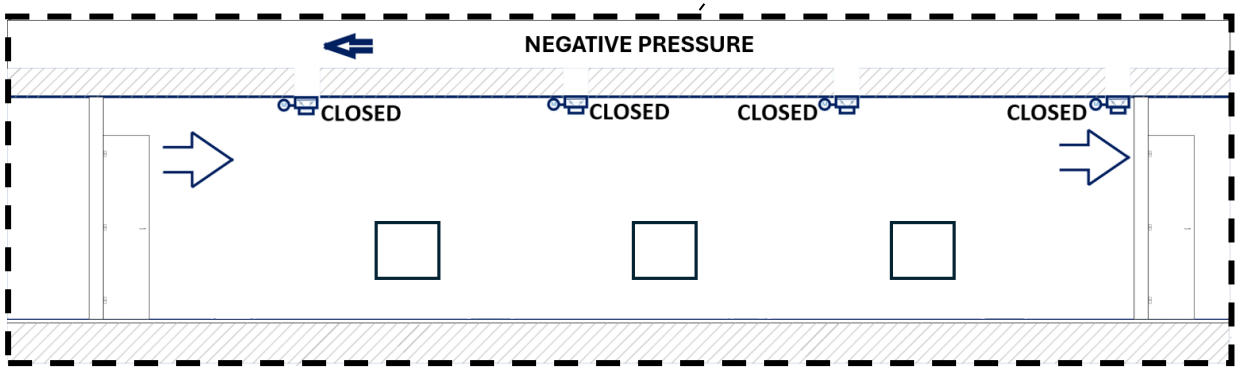
3. Update on tunnel concept *Longitudinal*

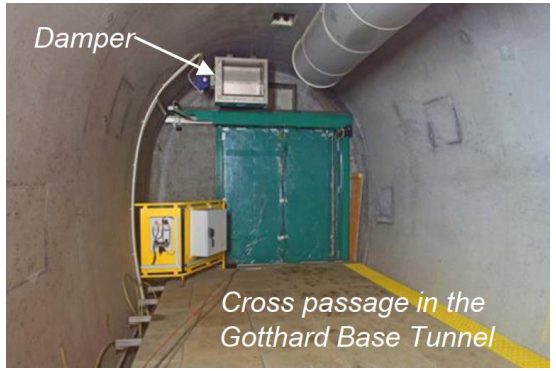


Run Mode → Machine is in operation

Access Modes → Maintenance / works are done in the tunnel

Flushing Mode → Full air renewal between Access and Run Modes





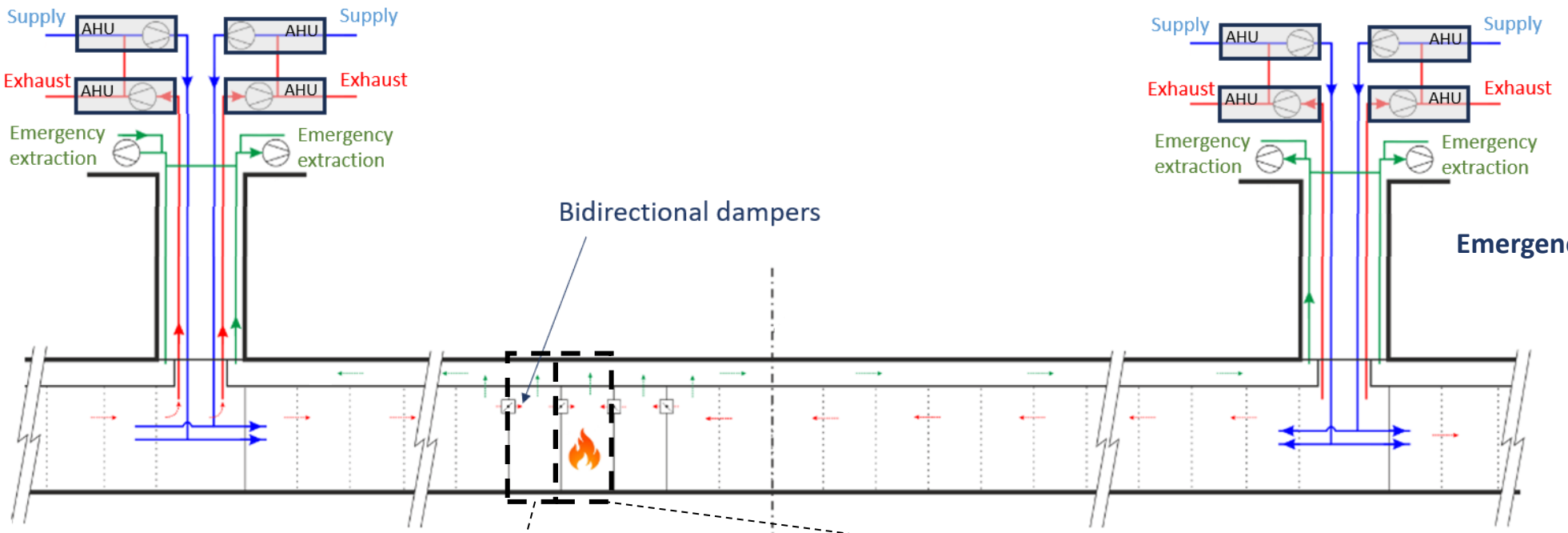
Advantages

- No slab duct needed
- Less and simpler controls (dampers,etc)
- More efficient overall, less pressure loss

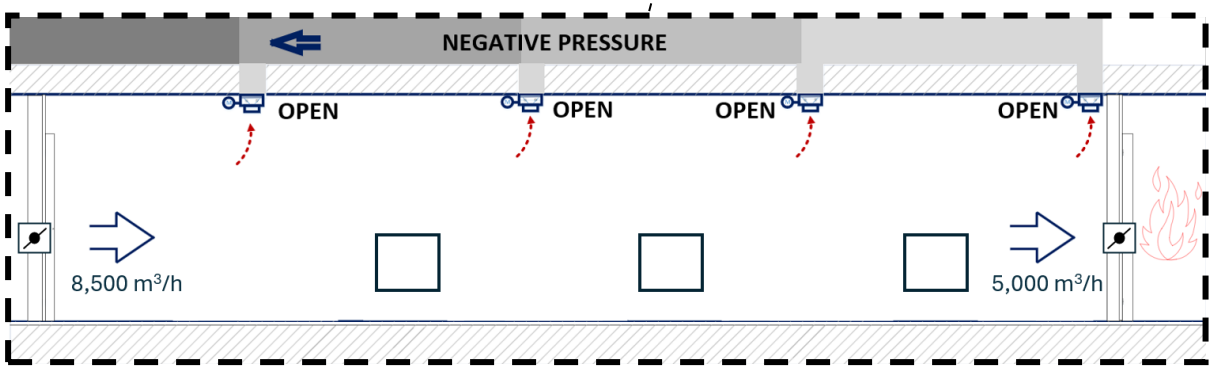
Challenges

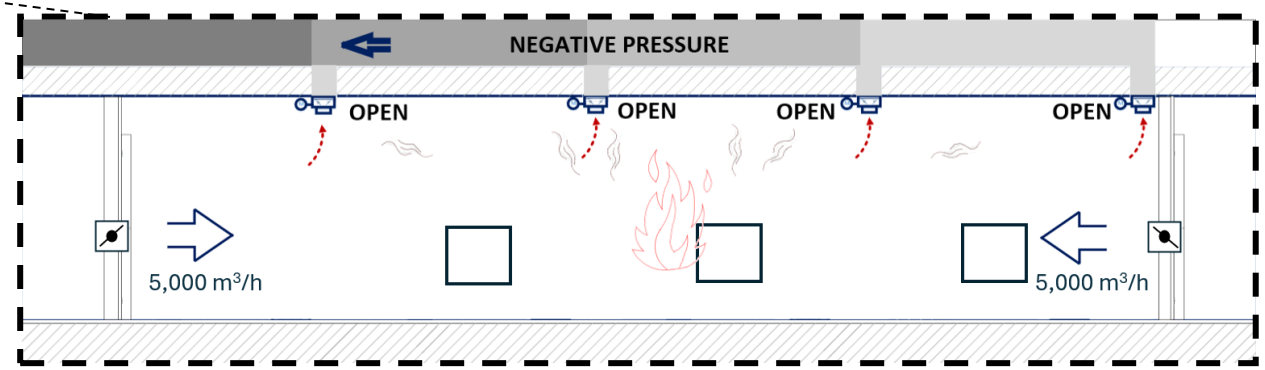
- Degraded modes
- Force needed to open compartment doors
- Larger dampers at compartment walls

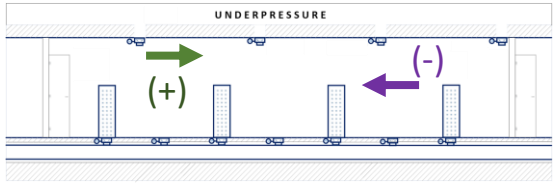
3. Update on tunnel concept *Longitudinal*



Emergency Mode → Smoke & fire or helium leak scenario







Signs criteria

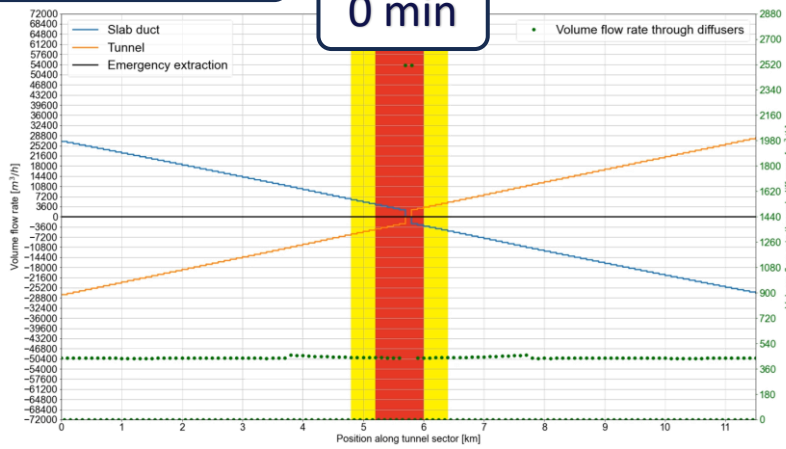
3. Update on tunnel concept

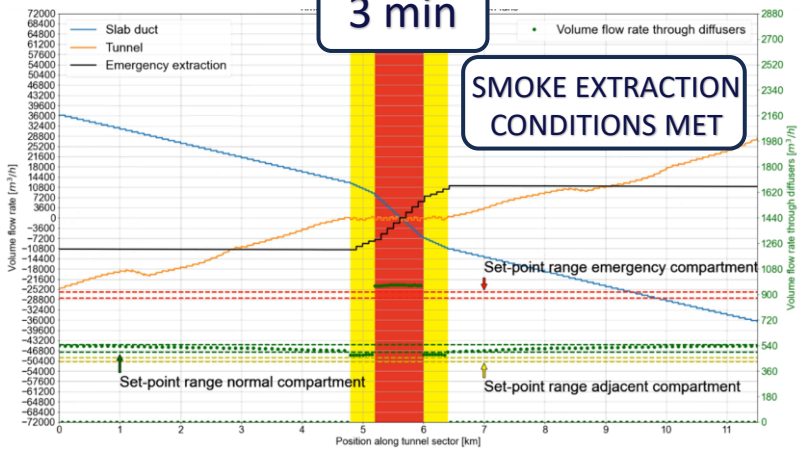
Adaptation Run / Access → Emergency

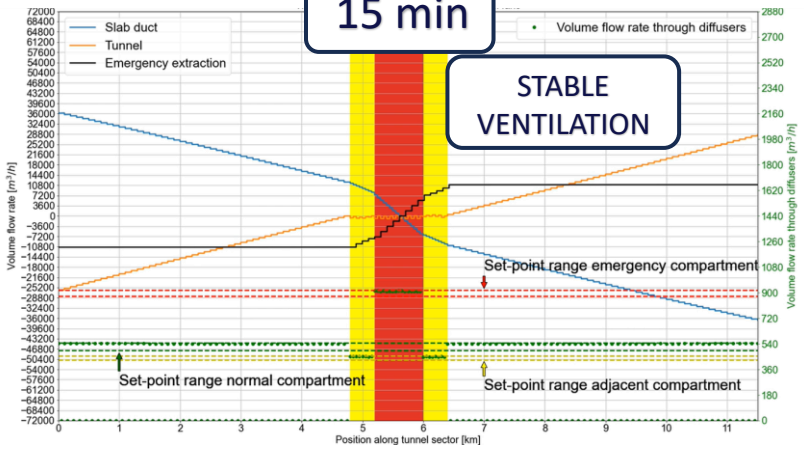
*Emergency in central compartment**

**With 7000 m³/h per affected compartment*

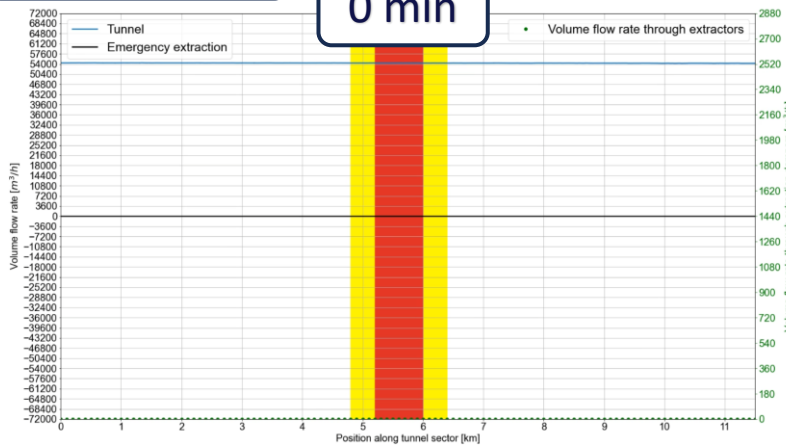
Semi-transverse

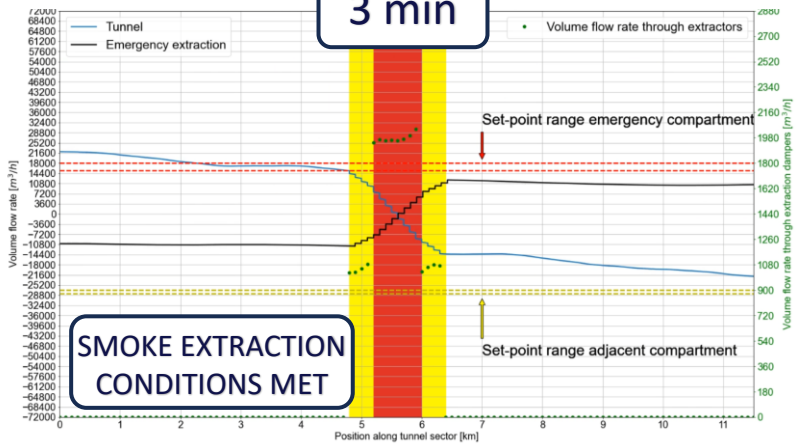


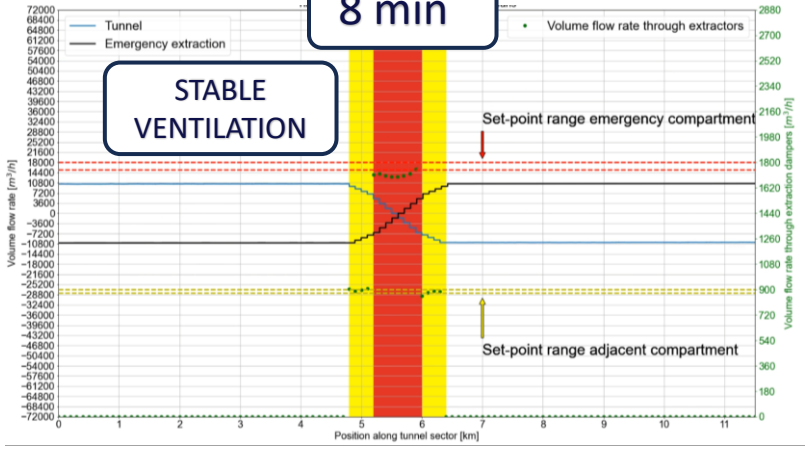


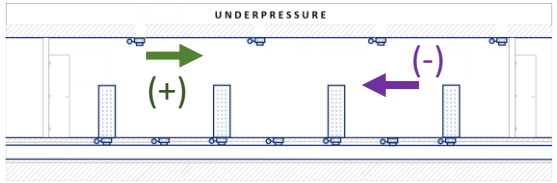


Longitudinal









Signs criteria

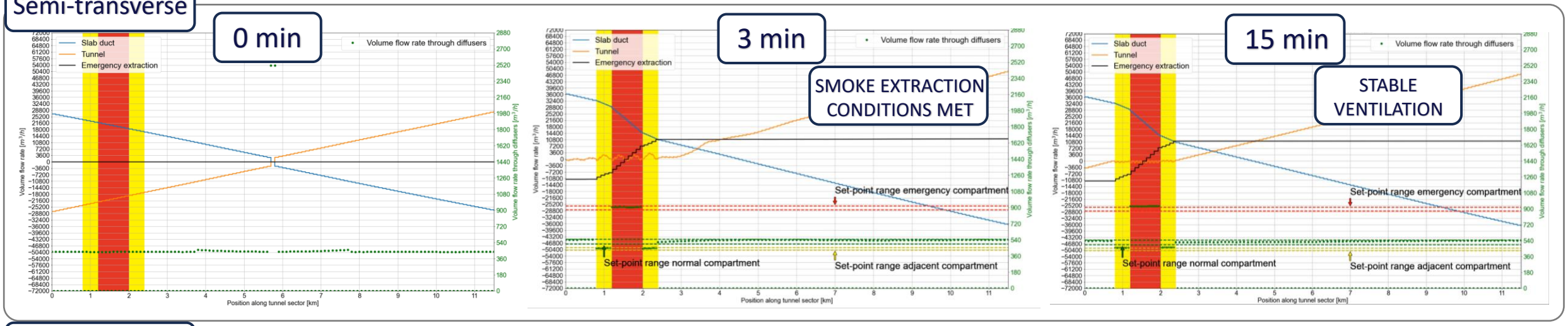
3. Update on tunnel concept

Adaptation Run / Access → Emergency

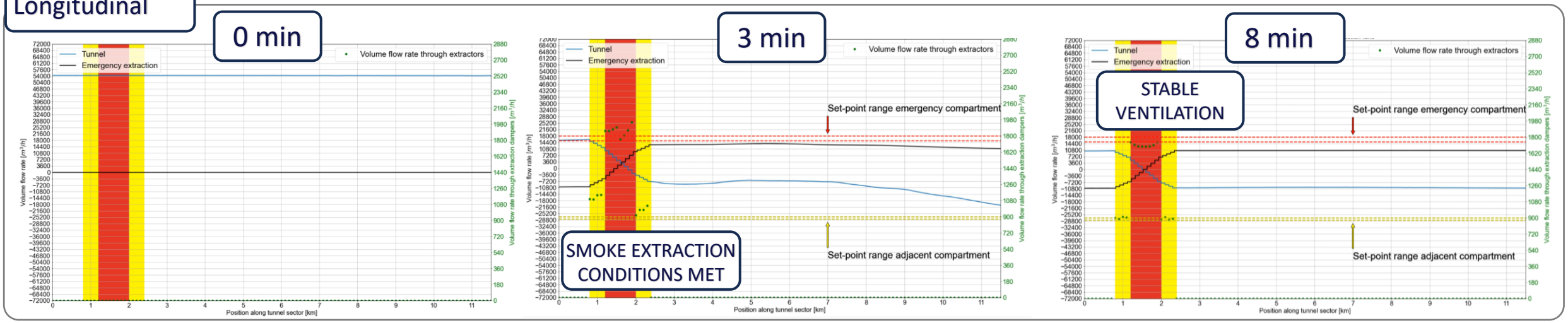
*Emergency in lateral compartment**

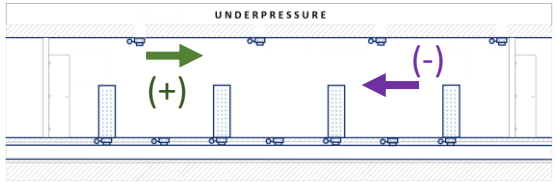
**With 7000 m³/h per affected compartment*

Semi-transverse



Longitudinal





Signs criteria

3. Update on tunnel concept

Fire heat effects

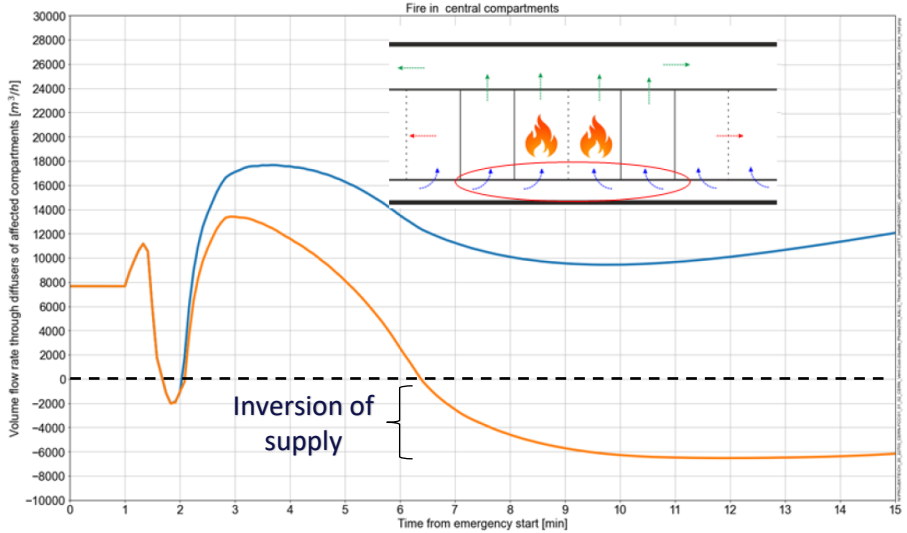
7000 m³/h per affected compartment
Considering heat release rate of fire

Local expansion of air due to fire heat

Inversion of the supply, Smoke leaves fire-affected compartment

Prevention by increase in airflow

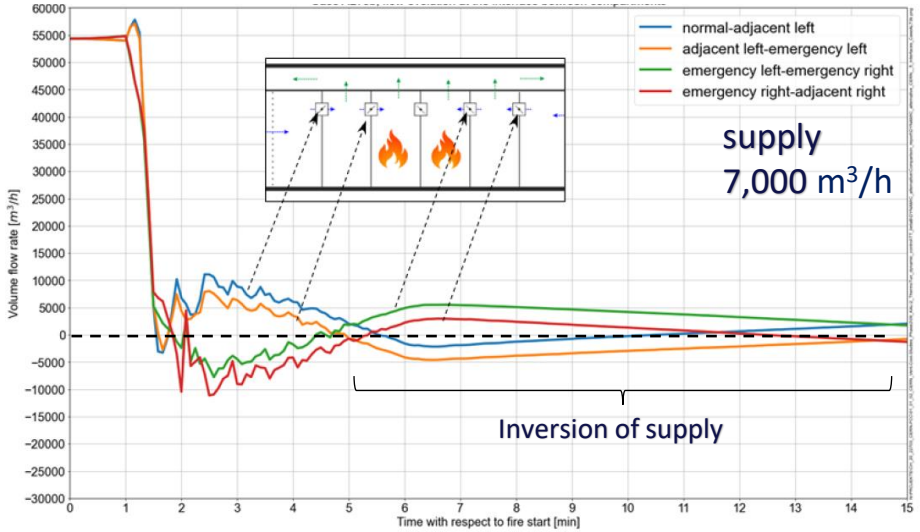
Semi-transverse

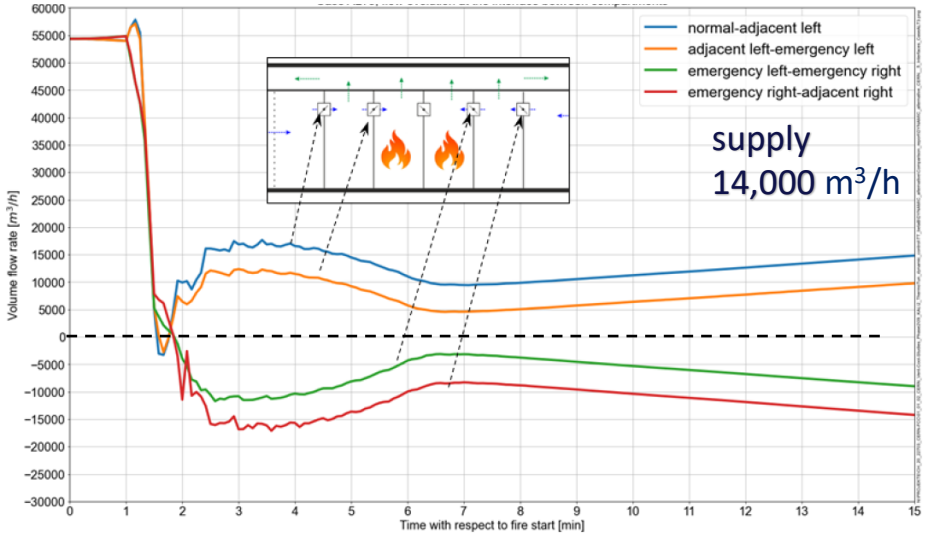


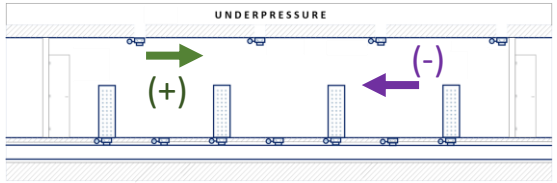
supply 14,000 m³/h

supply 7,000 m³/h

Longitudinal





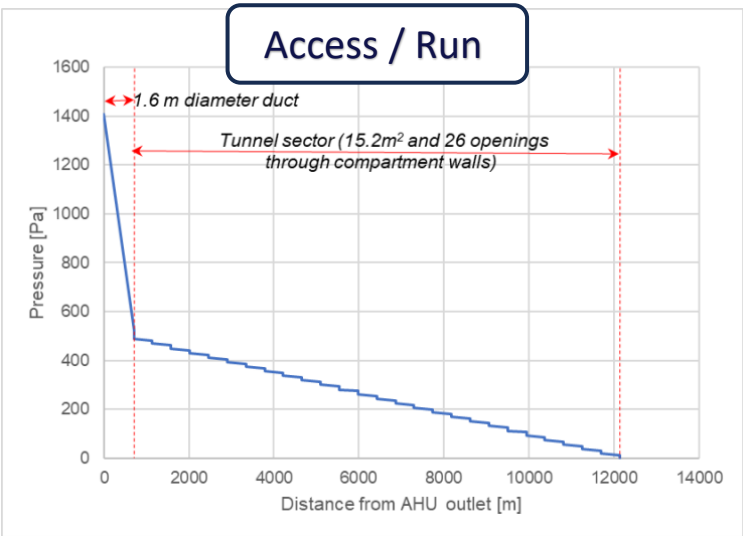


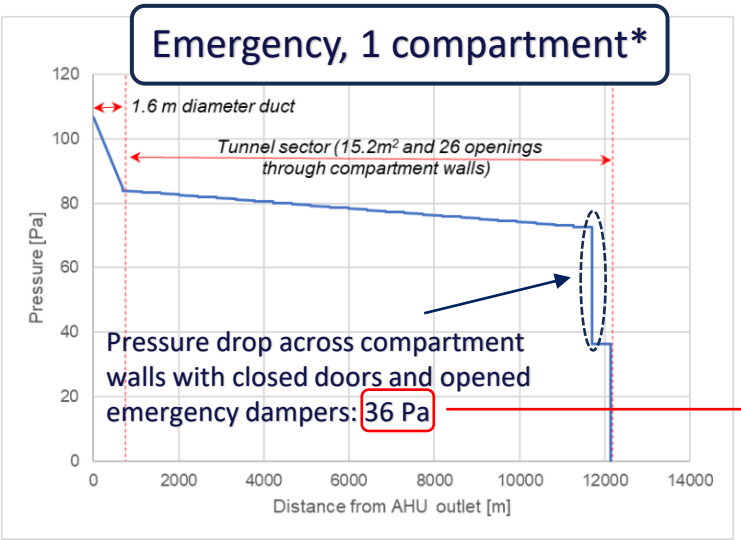
Signs criteria

3. Update on tunnel concept

Pressure differences

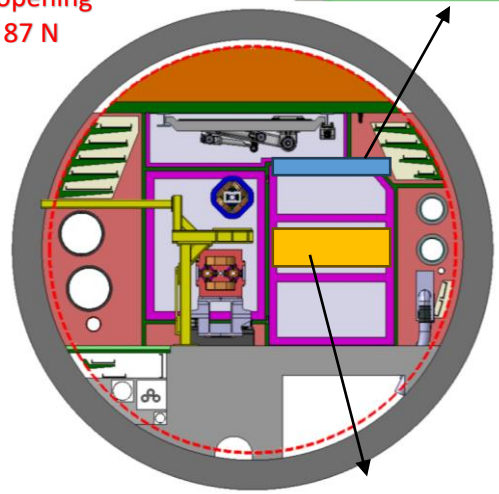
**With 10,000 m³/h per affected compartment, and a damper of 0.6 m²*

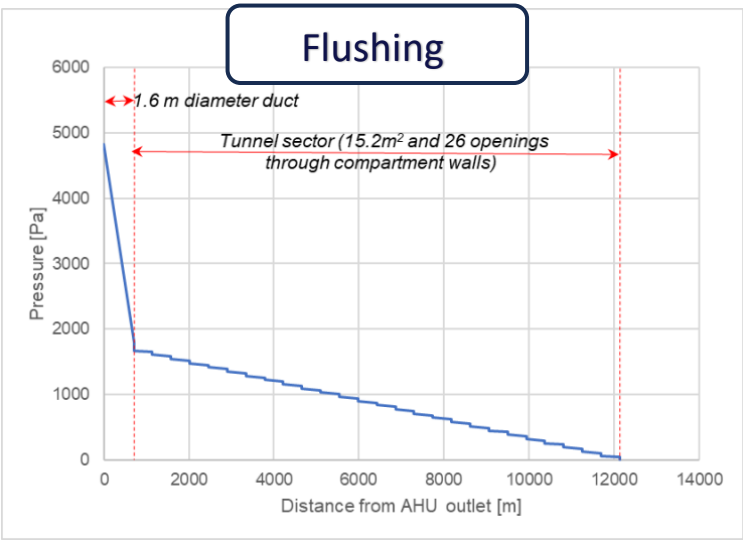


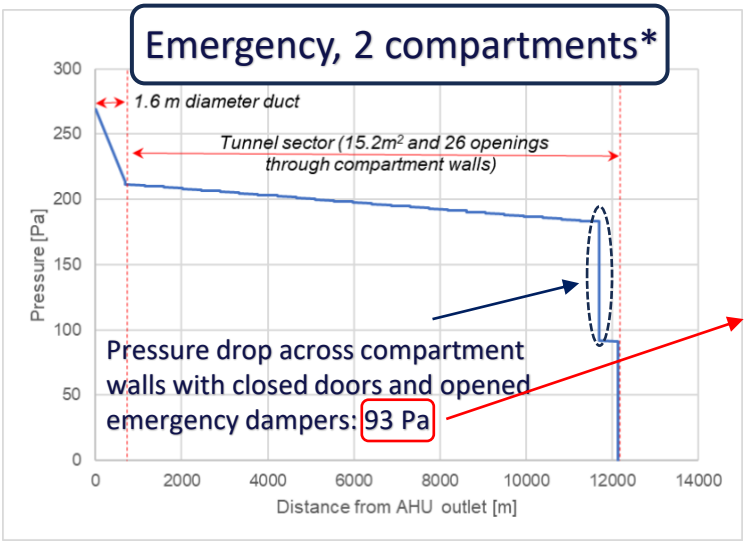


Maximum admissible opening force < 70 N

Required opening force = 87 N







Required opening force = 224 N

However, if damper increased to 1 m², we are below < 70 N in both cases.

Manual pressure relief damper in the door (by Hodapp).

3. Update on tunnel concept *Degraded modes*

4. Next steps

- Analyze and decide between the semi-transverse ventilation or changing to the longitudinal concept
- Interact with the rest of departments and exchange information: heat loads, ducts integration, sustainability considerations…
- Further refine the design of special areas like Klystron Galleries, connecting tunnels, etc.
- Proceed with the preTDR tasks defined for the ventilation part

Thank you
for your attention.

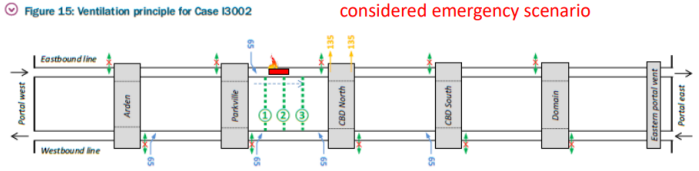
SPARES

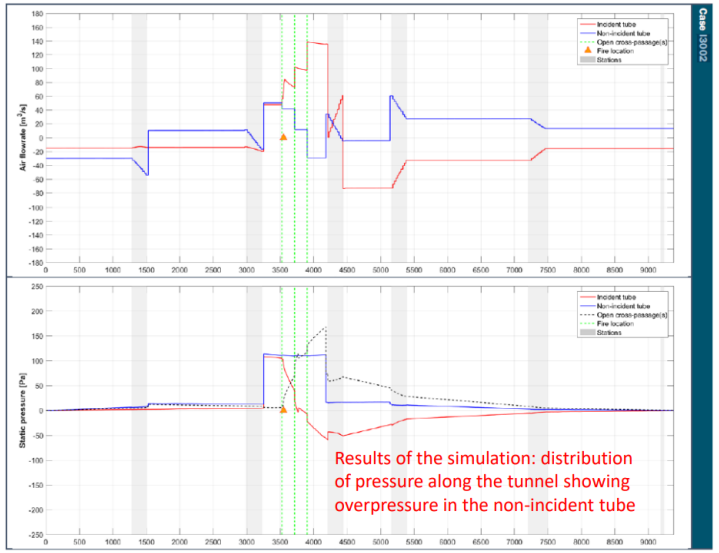
ThermoTun software *Transient simulations*

- 1D modelling software, developed by Dundee Tunnel Research and University of Dundee (Scotland).
- Transitory analysis of air pressures and velocities.

Metro Melbourne

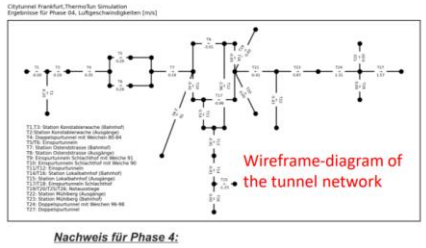
Schematics of the tunnel and the considered emergency scenario





Results of the simulation: distribution of pressure along the tunnel showing overpressure in the non-incident tube

Citytunnel Frankfurt



Wireframe-diagram of the tunnel network

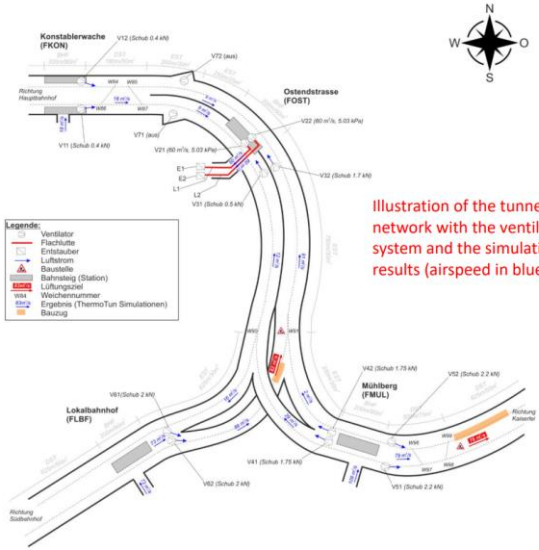
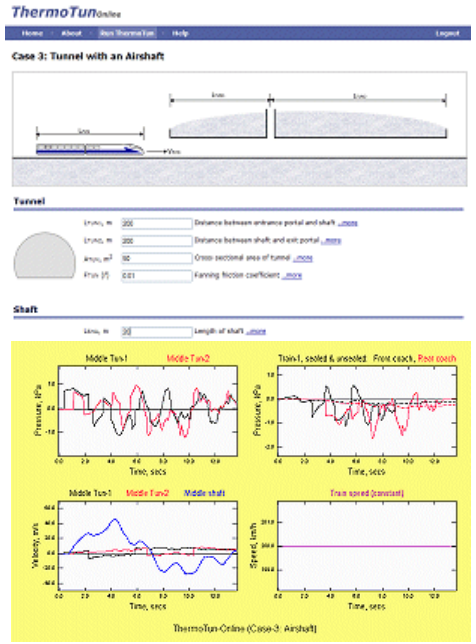
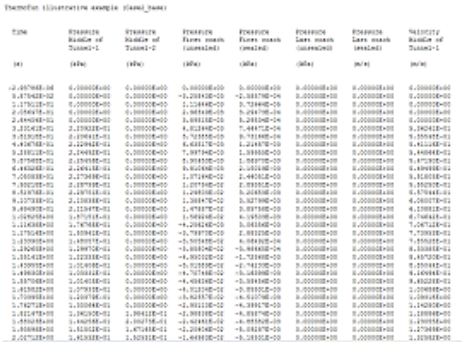


Illustration of the tunnel network with the ventilation system and the simulation results (airspeed in blue)





Simulations *Configuration*

Both the baseline, semi-transverse concept and the alternative, longitudinal concept are included in the simulations.

Easy controller 227V-024T-05-013	
Supply voltage ~	24 V AC ± 20%, 50/60 Hz
Supply voltage ⎓	24 V DC ± 20 %
Power rating ~	5 VA max.
Power rating ⎓	Max. 3 W
Run time for 90°	100 s
Setpoint value signal input	0 – 10 V DC, Ra > 100 kΩ
Actual value signal output	0 – 10 V DC, max. 0.5 mA
IEC protection class	III (protective extra-low voltage)
Protection level	IP 20
EC conformity	EMC to 2014/30/EU

Simulation of the Run Modes.

- Supply fans ramp up time: 60 s
- Setpoint in damper of baseline concept ramp up time: 100 s

Simulation of Emergency Modes.

- Timeline of events for transition from Run to Emergency Modes

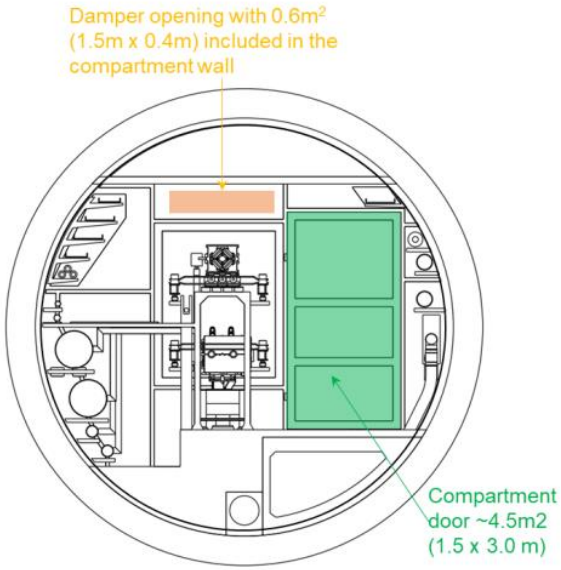
Time [s]	Event	Comment
<0	Normal operation mode	
0	Fire detection, alarm given	A reaction time/delay of 60s until confirmation of the fire alarm by the operator and/or activation of corresponding scenario is assumed
60	Stop normal ventilation (supply and normal extraction)	Avoid spread of smoke along the tunnel
60	Close doors of fire affected and adjacent compartments	Time to close: 30 s
60	Open emergency extraction dampers in ceiling duct of the fire affected and adjacent compartments	Time ot fully open the dampers: 30s
90	Start emergency extraction fans	Ramp up time for emergency extraction fans: 30s
90	Restart supply flow with distribution according to position of fire	Time to achieve target supply distribution: as per system reaction time accounting for VAV dampers opening/closing speed (100s from fully open to fully closed)

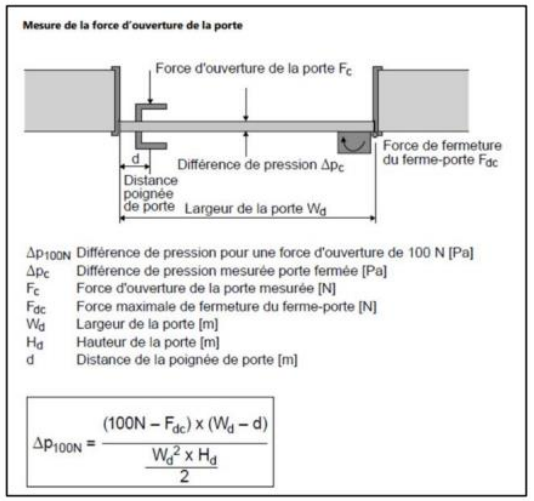
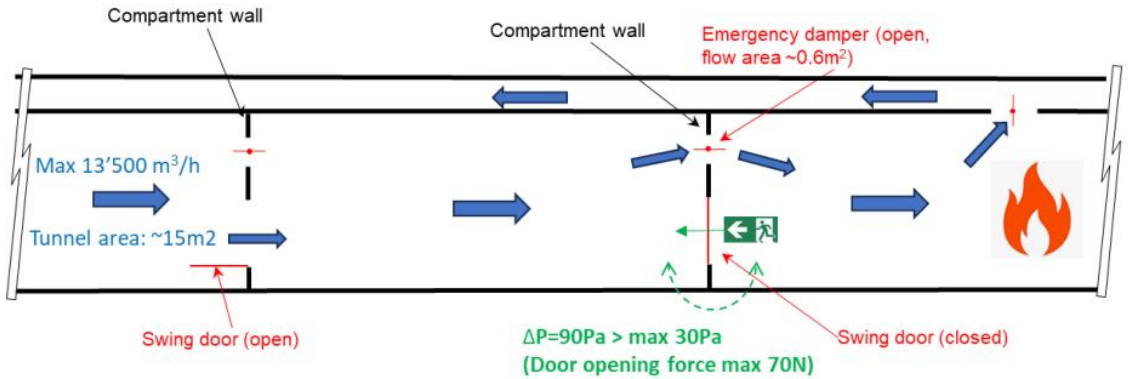
Longitudinal ventilation *Pressure on compartment door*

- Rectangular fire dampers with dimensions 1.5 m x 0.4 m (free area 0.6 m^2) are considered, to be moved from robot space.

- Pressure difference across compartment walls must not hinder the opening of integrated doors in case of emergency

- Maximal door opening force of 70 N shall not be exceeded. Accounting for the type and dimensions of the doors in the compartment walls (swing door with dimensions 1.5m x 3.0m), the maximal allowable pressure difference is 30 Pa.





From Etablissement Cantonal des Assurances, « Rôles et exigences des systèmes de mise en surpression », R07 – V01, 2016