COOLING & VENTILATION PLANTS

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Annual Meeting of the FCC study – Rome 14th April 2016

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- Main input data
    - Civil engineering layout
    - Heat loads
- Cooling plants
    - Requirements
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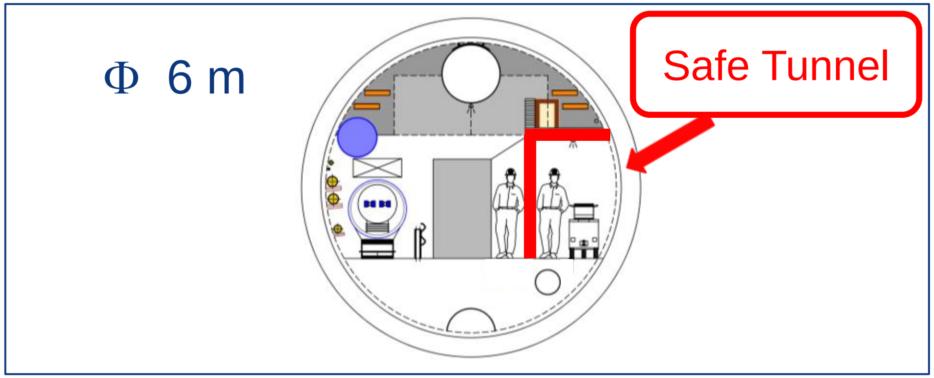
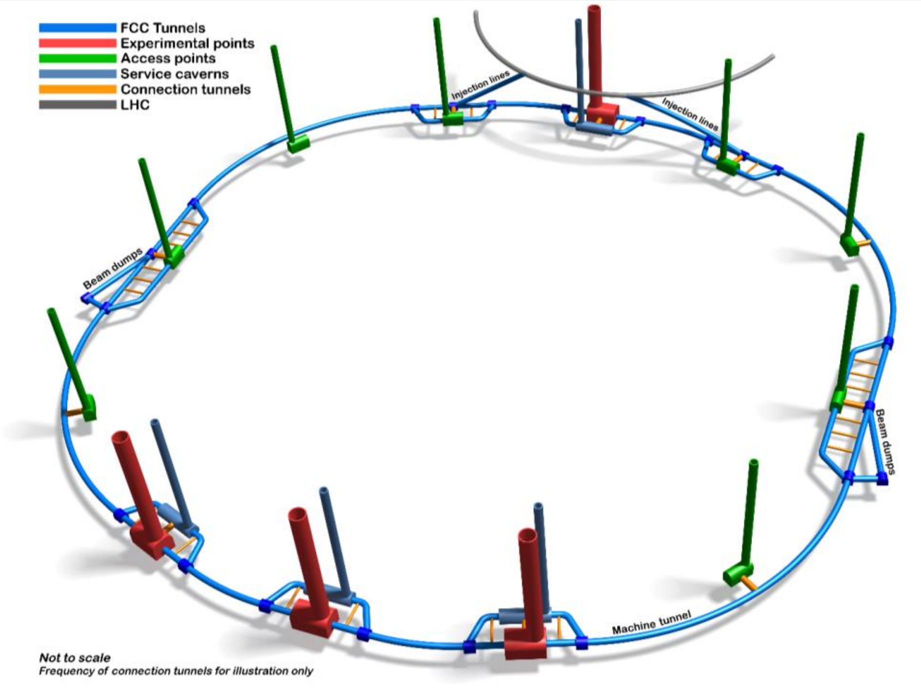
- Ventilation plants
    - Requirements
    - General architecture
- Services in the tunnel cross section
- Conclusions & next steps

Acknowledgements: G. Peon, A. Rakai, Members of I&O WG

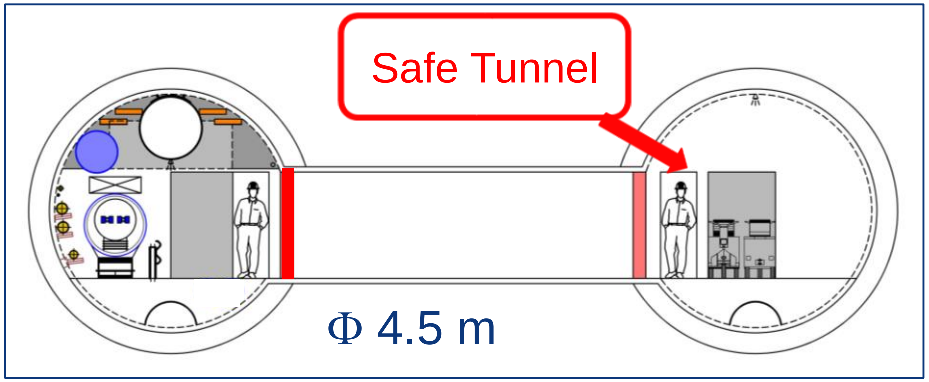
FCC Layout

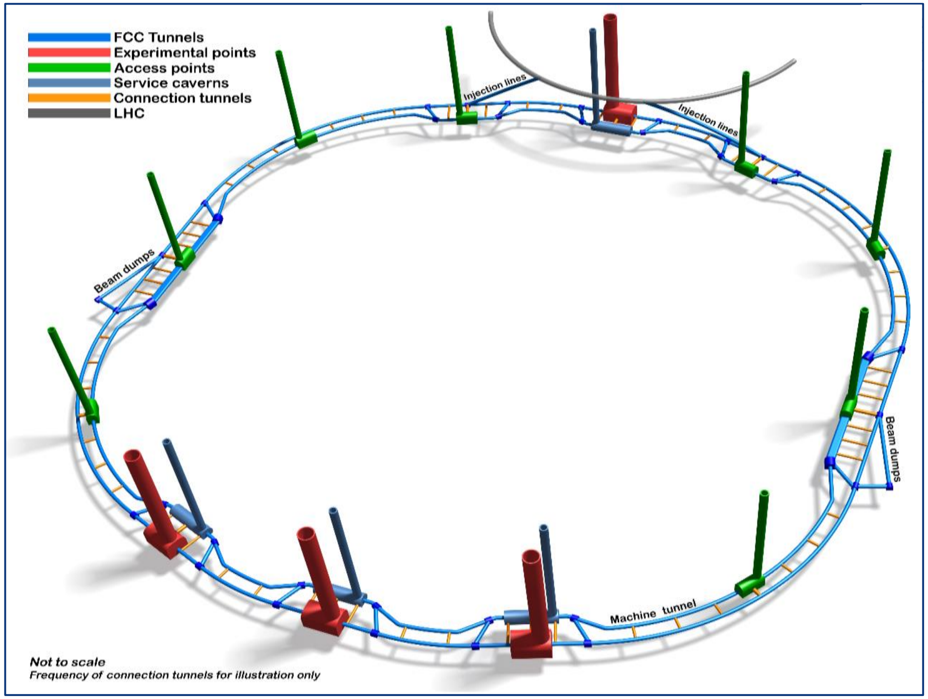
Single Tunnel Option





Double Tunnel Option





Impact on CV systems

Present studies focus on **how** we will comply with the requirements, not on **detail design** of each system.

The two options (one - two tunnels) do not have a major impact on the **choice of the technical solution** to adopt.

In addition, similar technical solutions can be proposed for the FCC-hh and for the FCC-ee.

Differencies on the size of the plant are based on the geometry and on specific heat loads.

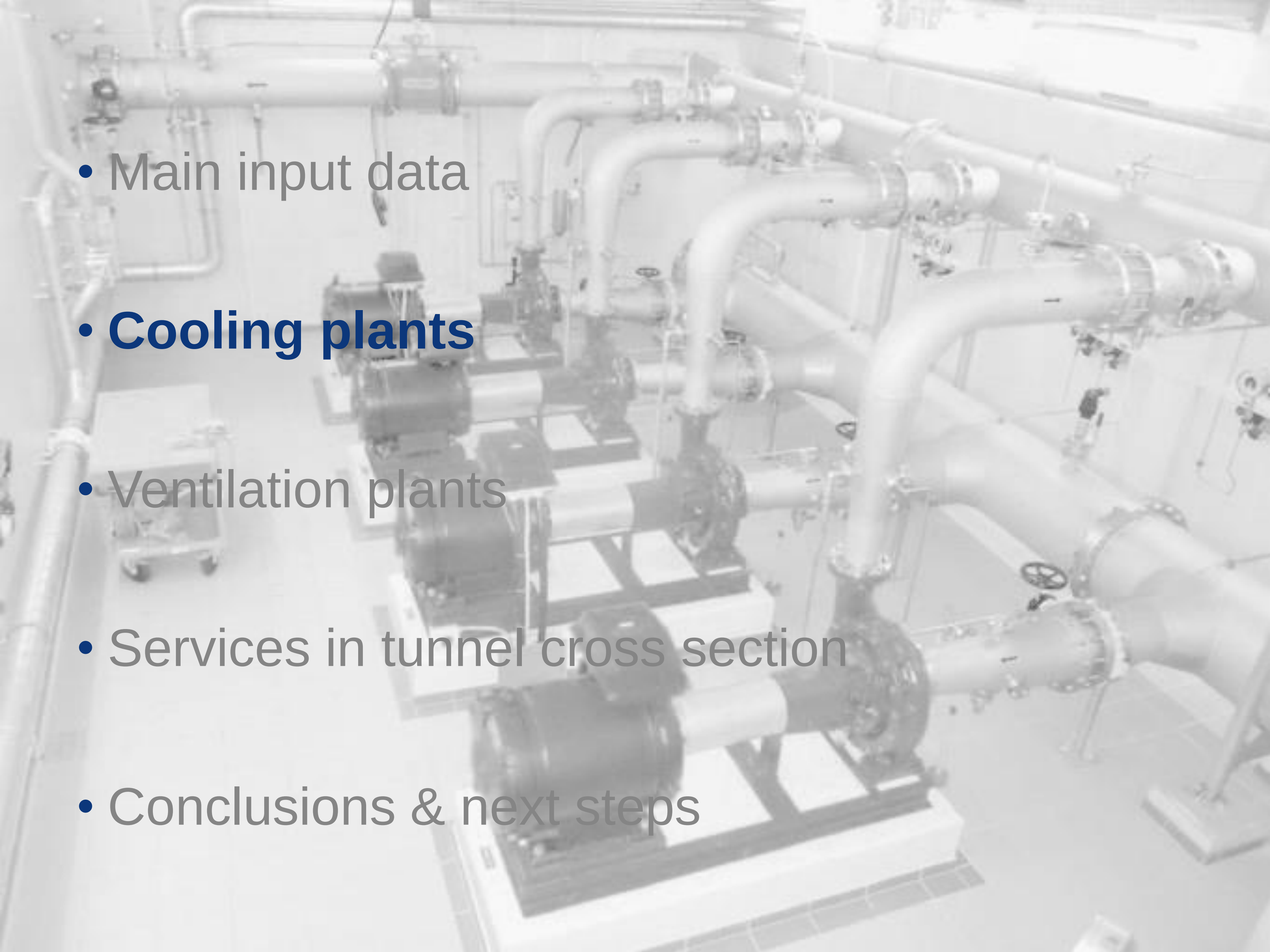
Where needed, **specific systems** will be implemented in case of high demanding requirements.

In the following slides the **FCC-hh option with one single tunnel is taken into account as baseline for this talk.**

Technical heat loads FCC-hh

	WATER		AIR		
	Surface [MW]	**Underground [MW]**	**Surface [MW]**	**Underground [MW]**	**TOTAL [MW]**
Magnets	0	10.7	0	1.2	**11.9**
Cryogenics	204	13	8	1	**226**
RF	0	9	0	1	**10**
Power converters	2.8	0	0.3	0	**3.1**
HV Cables	0	0	0	1.9	**1.9**
Experiments	35.6	9.4	3.9	1.1	**50**
Others	24	0	6	0	**30**
TOTAL	**266.4**	**42.1**	**18.2**	**6.2**	

TOTAL TECHNICAL HEAT LOAD: 332.9 MW



- Main input data
- **Cooling plants**
- Ventilation plants
- Services in tunnel cross section
- Conclusions & next steps

Requirements to cooling plants

- Reliability of systems
- Operability although long distances & altitude variations:
  - Leaks, pressure losses, static pressure
- Minimize environmental impact:
  - Noise
  - Visual impact
  - Water consumption
- Cost

FCC-hh: heat loads cooling circuits [MW]

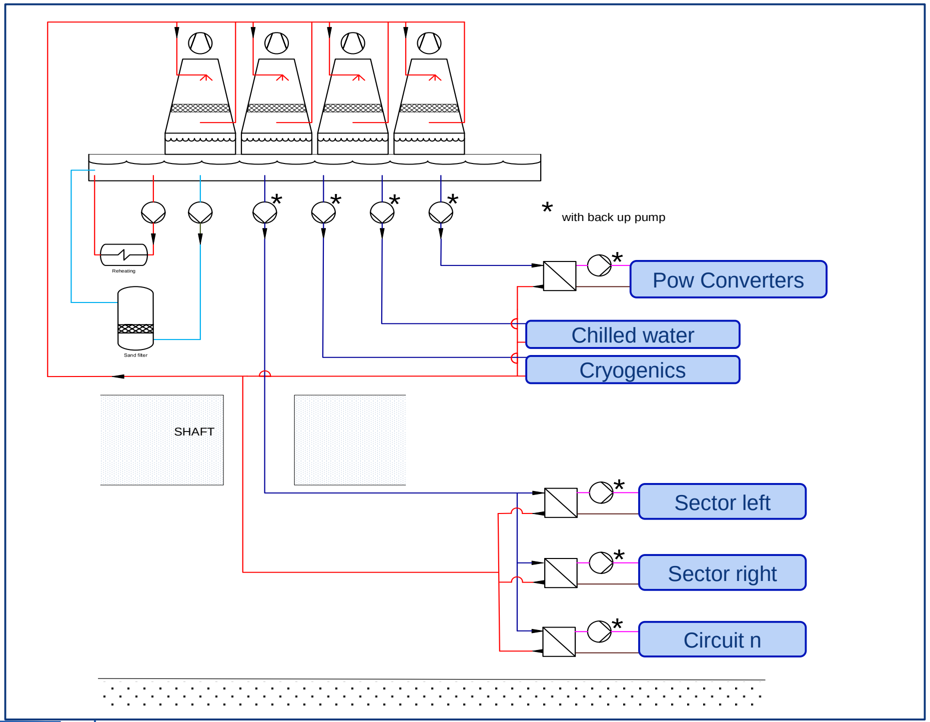
MW	L-A	As	Au	A-B	…s	Bu	B-C	Cs	Cu	C-D	Ds	Du	E-D	Es	Eu	E-F
Cryo		20	1.3					41	2.6					41	2.6	

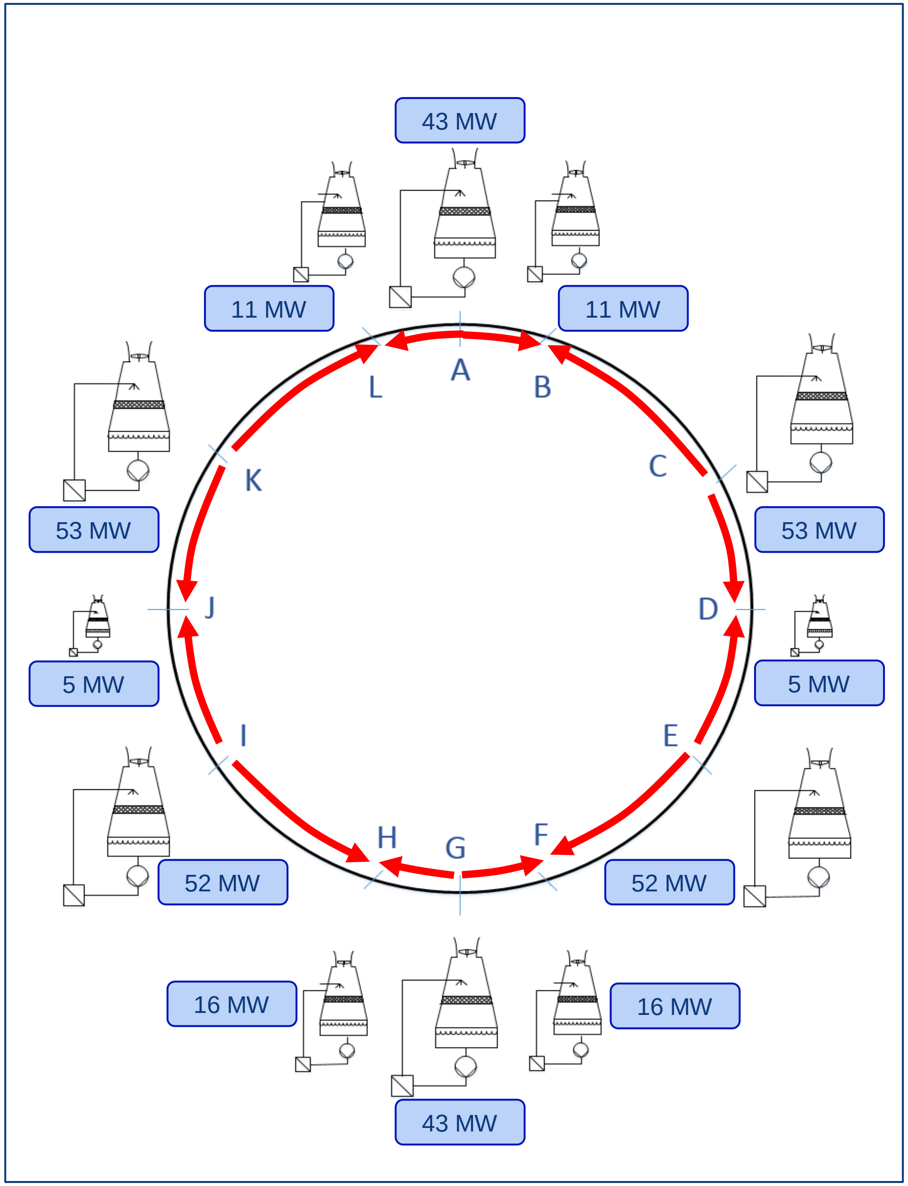
MW	Fs	Fu	F-G	Gs	Gu	G-H	Hs	Hu	H-I	Is	Iu	I-J	Js	Ju	J-K	Ks	Ku	K-L	Ls	Lu
Cryo				20	1.3															
RF																				
Exper	7.3	2		10.5	2.7															
Gen services	2			2																
Magnets			0.5																	
Pow converters	0.1			0.1																
Chilled water	3			5.4																
Total	12.4	2	0.5	38	4															
Total point	**14.4**		**43**																	

POINT A	Power kW	ΔT K	Q m3/h	ND mm	H bar
Primary	**43,000**	**15**	**2,470**	**550**	**1.2**
Primary (shaft)	**3,700**	**15**	**213**	**200**	**2.0**
Cryogenics S	20,000	15	1,149	400	1.3
Experiments S	10,500	15	603	300	1.6
Gen services	2,000	15	115	150	2.7
Chilled water	5,400	6	775	350	1.4
Power converters	100	15	6	50	1.7
Cryogenics U	1,300	15	75	125	1.4
Tunnel circuit L-A	500	15	29	125	4.6
Tunnel circuit A-B	500	15	29	125	4.6
Experiments U	2,700	15	155	150	2.2
make up water (5%)			124	150	1.0

Cooling plants for FCC-hh

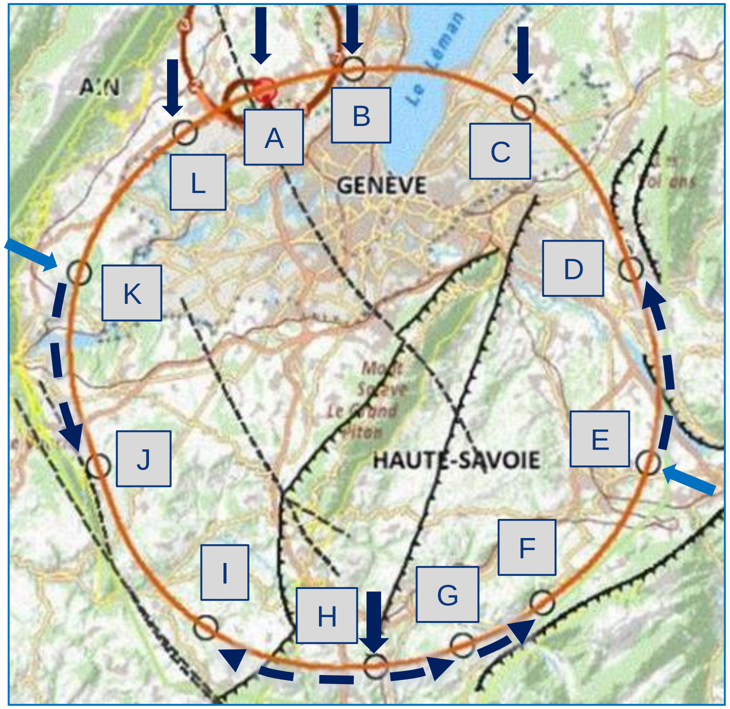
- One cooling plant in each Point :
  - Surface buildings
  - Underground equipment in cavern
- Alternate Points: one station in cavern cooling two adjacent sectors
- N+1 redundancy for main equipment





Water supply in FCC Points

- Main user: make up water for cooling towers
- Around half of the Points should be directly fed by water from local network.
- Other Points supplied by underground pipeline cast in the concrete slab of the tunnel.



- Fire fighting in underground:
  - make up water pipe (where existing)
  - dedicated pipe in other sectors.
- Fire fighting in surface:
  - preferably from local network.

Constraints - specificities

Underground depth (400 m):

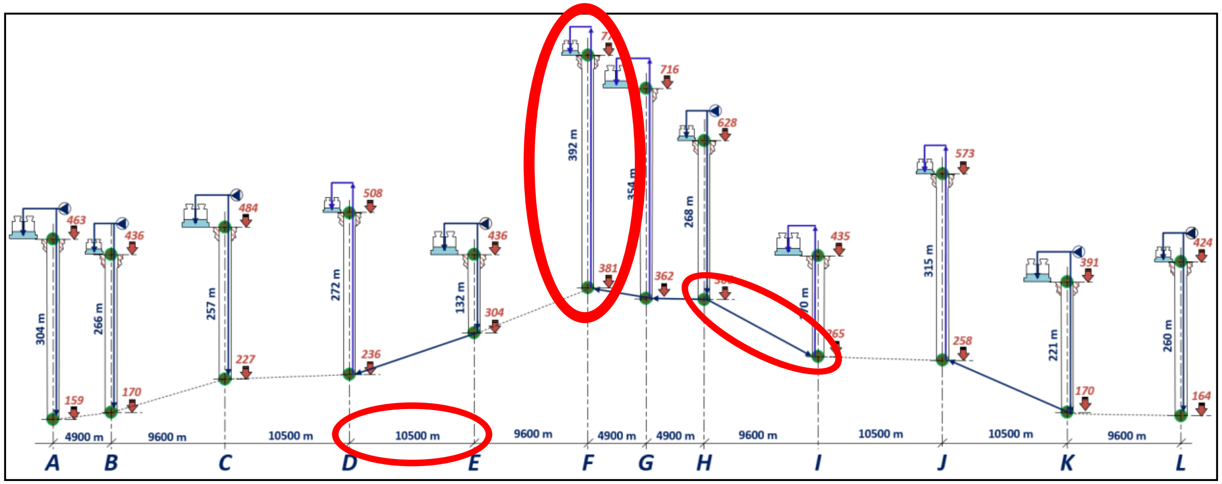
- static pressure 40 bars
- separate circuits between surface & underground.

Sector length (10 km):

- 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).

Altitude variation in sector:

- max ~100 m → 10 bar
- reduce pressure in tunnel at manifold level,
- differential pressure reducer on each manifold.



- Main input data
- Cooling plants
- **Ventilation plants**
- Services in tunnel cross section
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Requirements to Ventilation Plants

- Reliability of systems:
  - Heat loads
- Safety related:
  - Tunnels: air speed between 0.7 and 1.4 m/s
  - Pressure cascades:
    - Fire safety: safe area → technical area: 20 Pa
    - Higher radiation area → lower radiation area: 20 Pa
  - Smoke and He extraction
- Cost

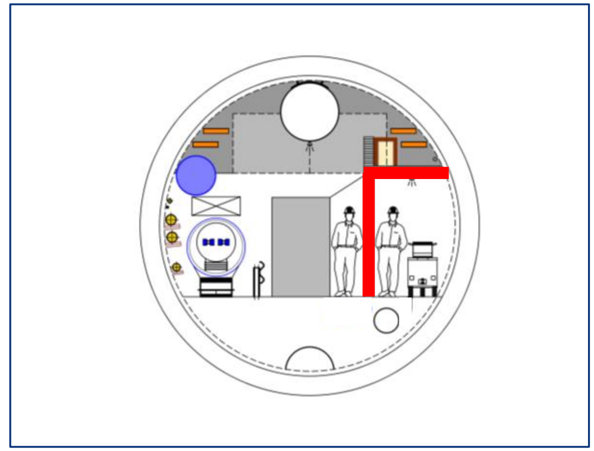
Air speed - operating conditions

Accelerator tunnel

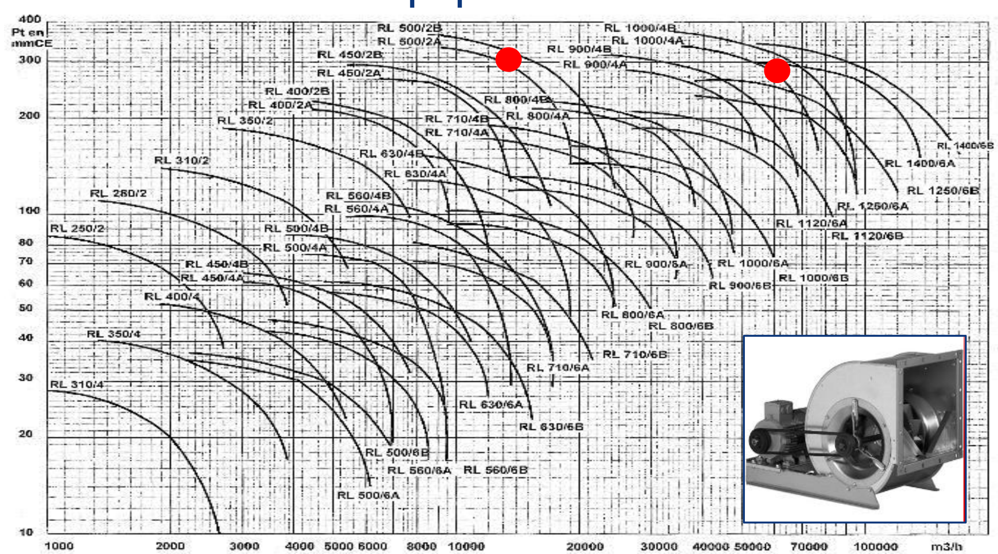
	1	2	3
Volume change/hr	0.4	0.6	1.2
Flow rate [m3/h]	55000	82000	165000
Air speed [m/s]	1	1.5	3
Distributed pressure loss [Pa]	40	90	360
Localised pressure loss [Pa]	10	23	92
Total pressure loss [Pa]	50	113	452

Safe tunnel

	1	2	3
Volume change/hr	0.43	0.65	1.3
Flow rate [m3/h]	16500	24800	49600
Air speed [m/s]	1.1	1.6	3.2
Total pressure loss [Pa]	49	111	440

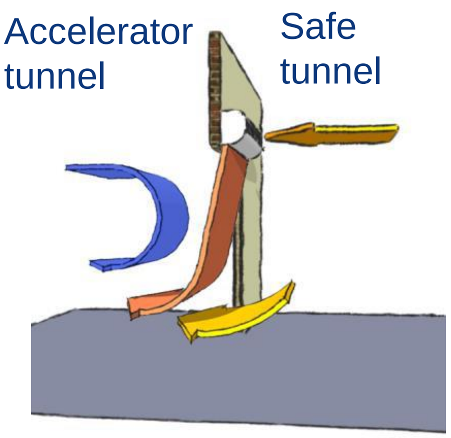


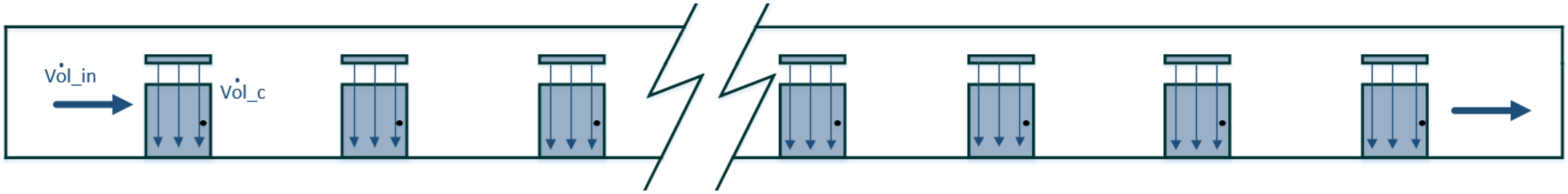
Standard equipment – industrial fans



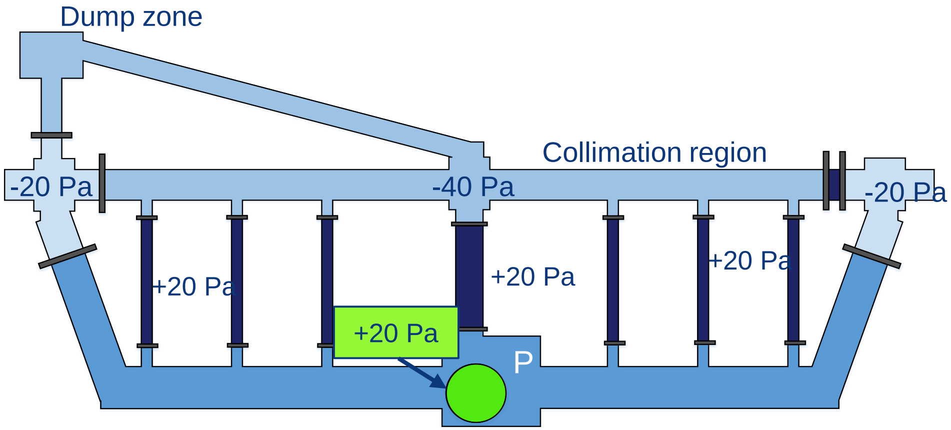
Pressure cascade: main features

- One ventilation system per zone to manage pressure difference wrt adjacent areas.
- Use of air locks for connecting galleries.
- Overpressure for safe tunnel ensured by dedicated devices at each passage among the two areas (air curtains – air locks):
  - Independent from number of doors opened
  - Failure of one equipment does not affect safety in other passages.

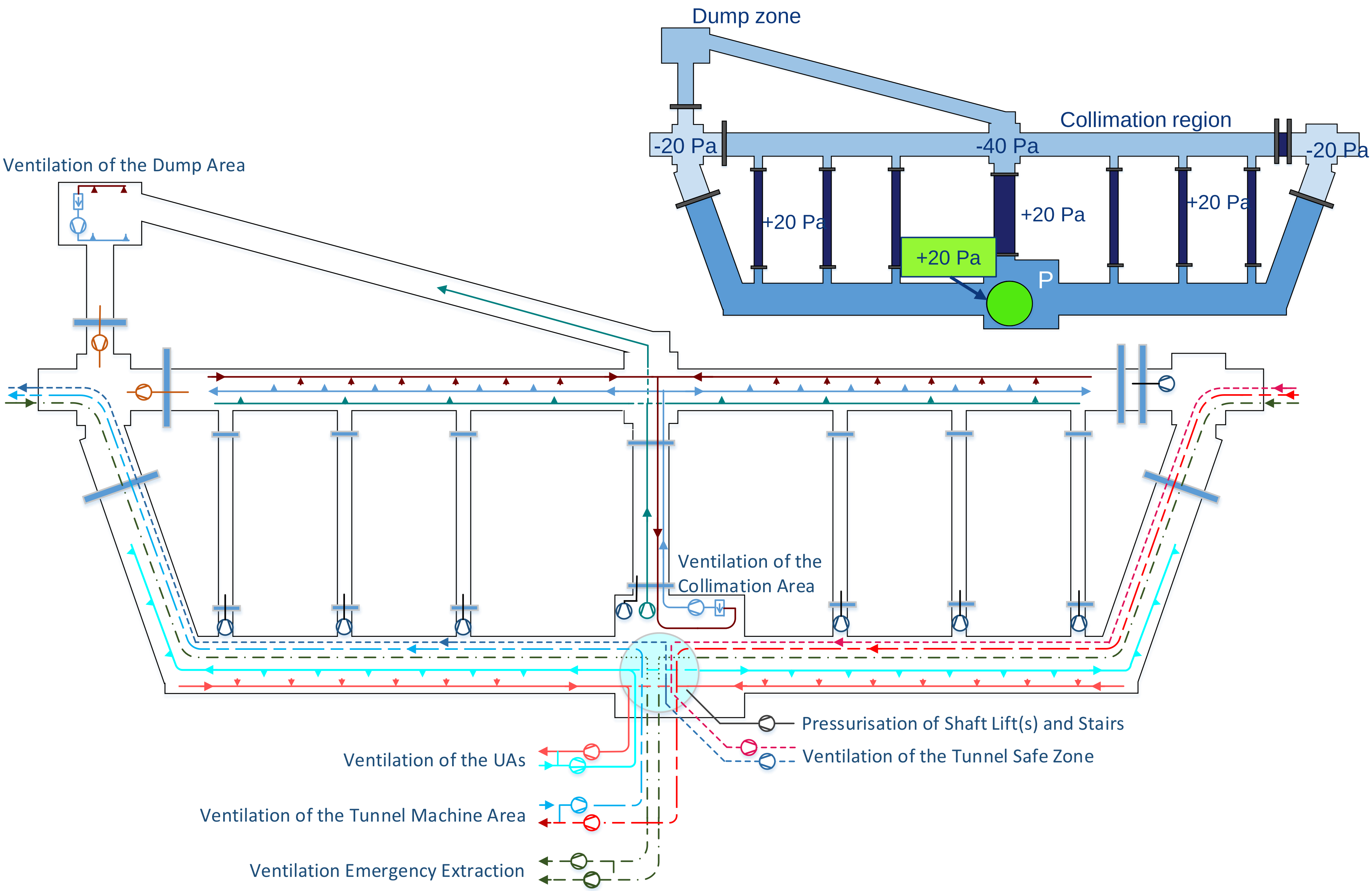




Ventilation of the FCC underground

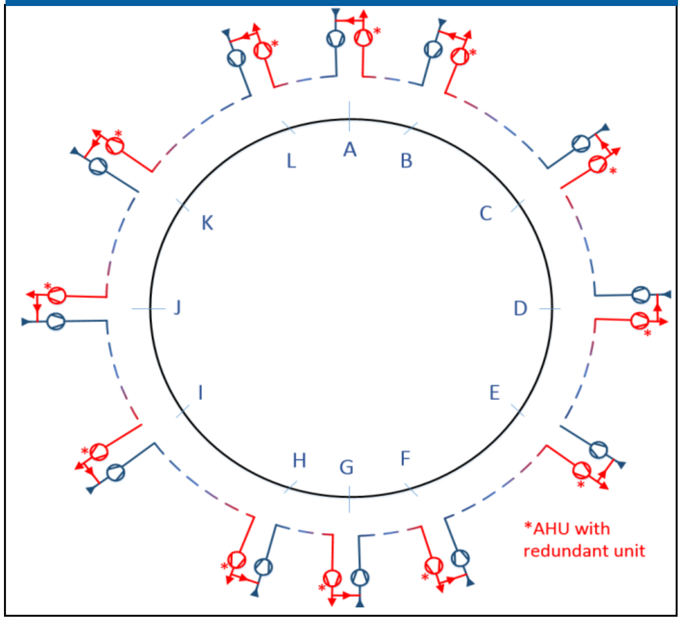


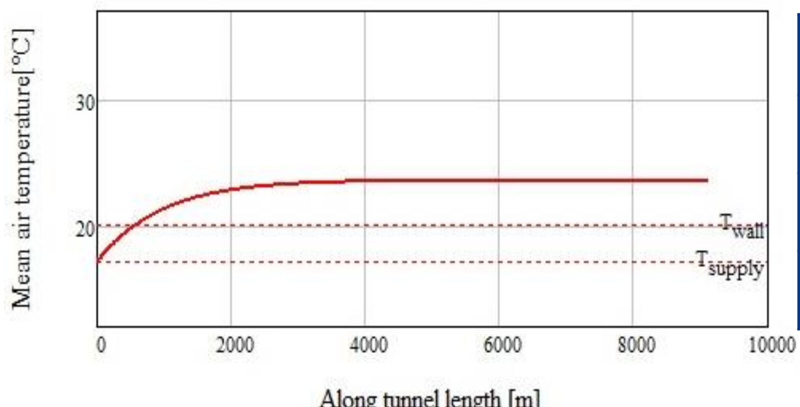
Ventilation of the FCC underground



Ventilation Scheme

Accelerator & safe tunnel





Tunnel wall temperature: 20 °C
Air temperature increase in tunnel: 8 °C
Temperature: 17 °C - 25 °C

Air recycling (values for accelerator tunnel):

- Use of free cooling
- 21% of time on full fresh air configuration

☹ Need for (minimum) 12 additional extraction AHUs

☺ Reduce energy consumption of 11.5 MWh/ yr.

ROI < 3 years

T [°C]	**< 5°C**	**5 ÷ 10**	**10 ÷ 17**	**17 ÷ 22**	**22 ÷ 25**	**>25**
Hr/year	2’197	1’823	2’544	1’337	475	384
%	25%	21%	29%	15%	6%	4%
Recycling	Partial			No		Full

(Statistics 2000 – 2014)

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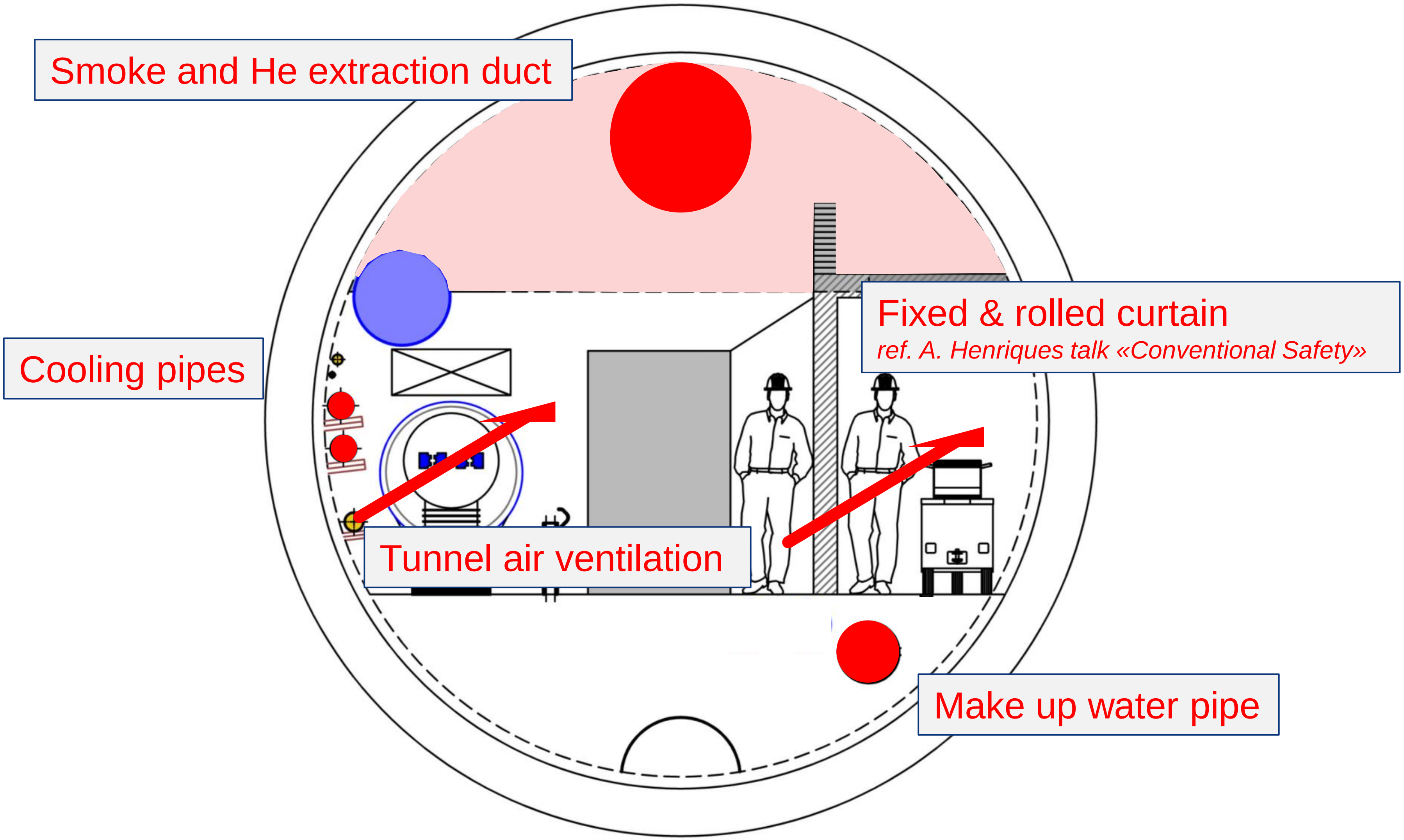
Cooling and ventilation services in tunnel



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Conclusions & next steps

- The general architecture has been defined.
- Mainly industrial existing solutions foreseen.
- Detailed studies for different options will follow.
  - Custom made solutions to be applied wherever necessary.
- Further studies will focus on:
  - Environmental impact,
  - Improve overall efficiency of the systems,
  - Valorisation of waste heat.

THANK YOU FOR YOUR ATTENTION