COOLING AND VENTILATION IN THE TUNNEL

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This is a preliminary study.
Some concepts are presented based
on estimated values to be confirmed.
The confirmation of rate air/water is still standing.

Ventilation

- Ventilation functions
- Heat load levels
- HVAC principle
- Tunnel section
- Safety
- Equipment
- Perspectives

Cooling

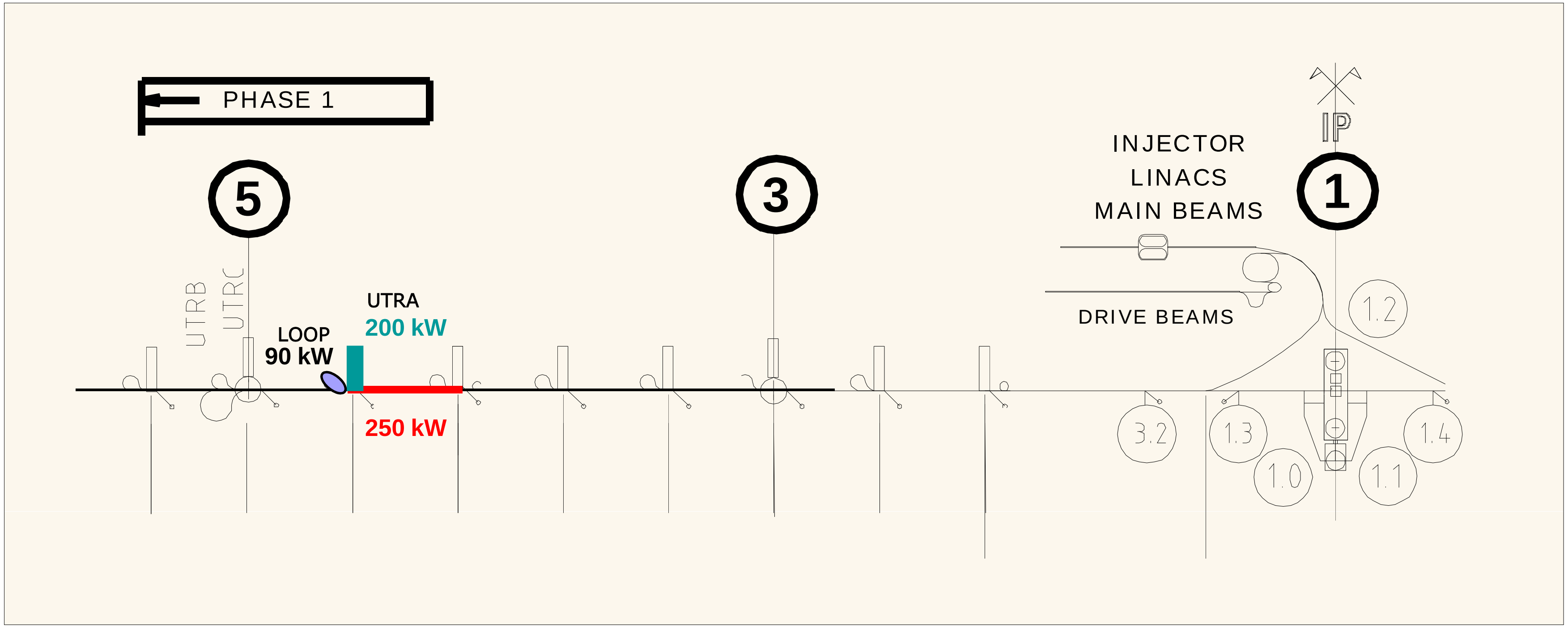
- Water cooling requirements
- Fluid circuits
- Cooling principle
- Main cooling station
- Tunnel section. Piping
- Equipment
- Perspectives

Tunnel ventilation functions

- Fresh air for people and ventilation (obligation).
- Requested ambient conditions (T°C and humidity).
- Remove heat loads in the air.
- Prevent from any air stratification, condensation.
- Purge before access.
- Smoke or gas extraction (obligation).
- Overpressure control linked to radiation (obligation).

Heat loads in the air

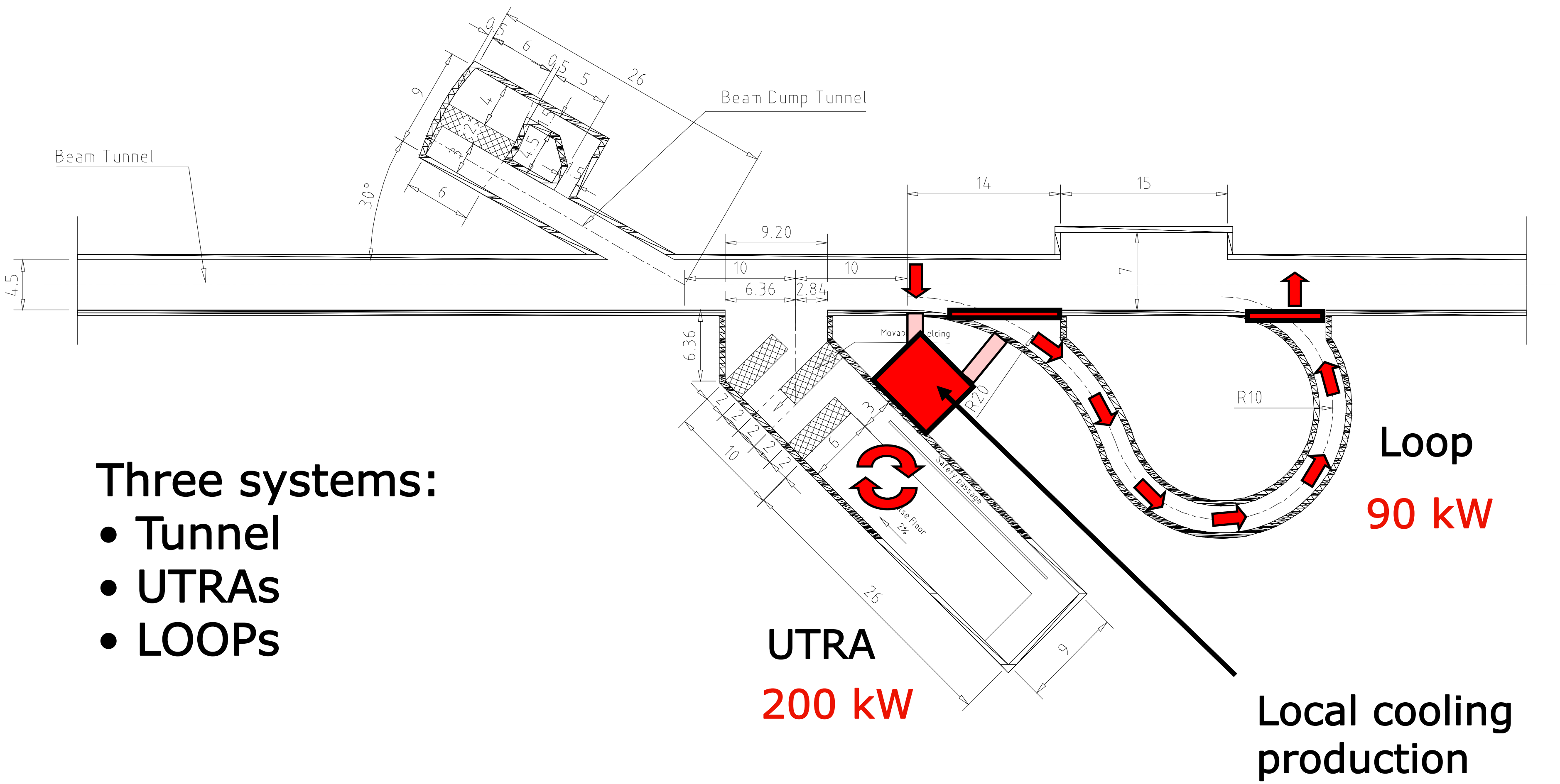
Drive Beam sector = 250 kW
UTRA cavern = 200 kW
Loop = 90 kW



Heat loads in the tunnel:
250 kW / DB sector
1250 kW between two shafts

Heat loads in the Loops & UTRA:
290 kW / DB sector
1450 kW between two shafts

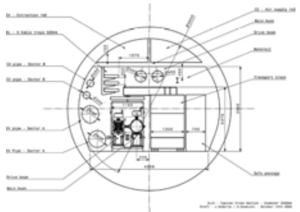
HVAC of underground areas



Three systems:
- Tunnel
- UTRAs
- LOOPs

Tunnel Air flow rate considerations

Tunnel section = 20 m^2
DB sector volume =17 000 m^3
Inter shaft volume = 90 000 m^3

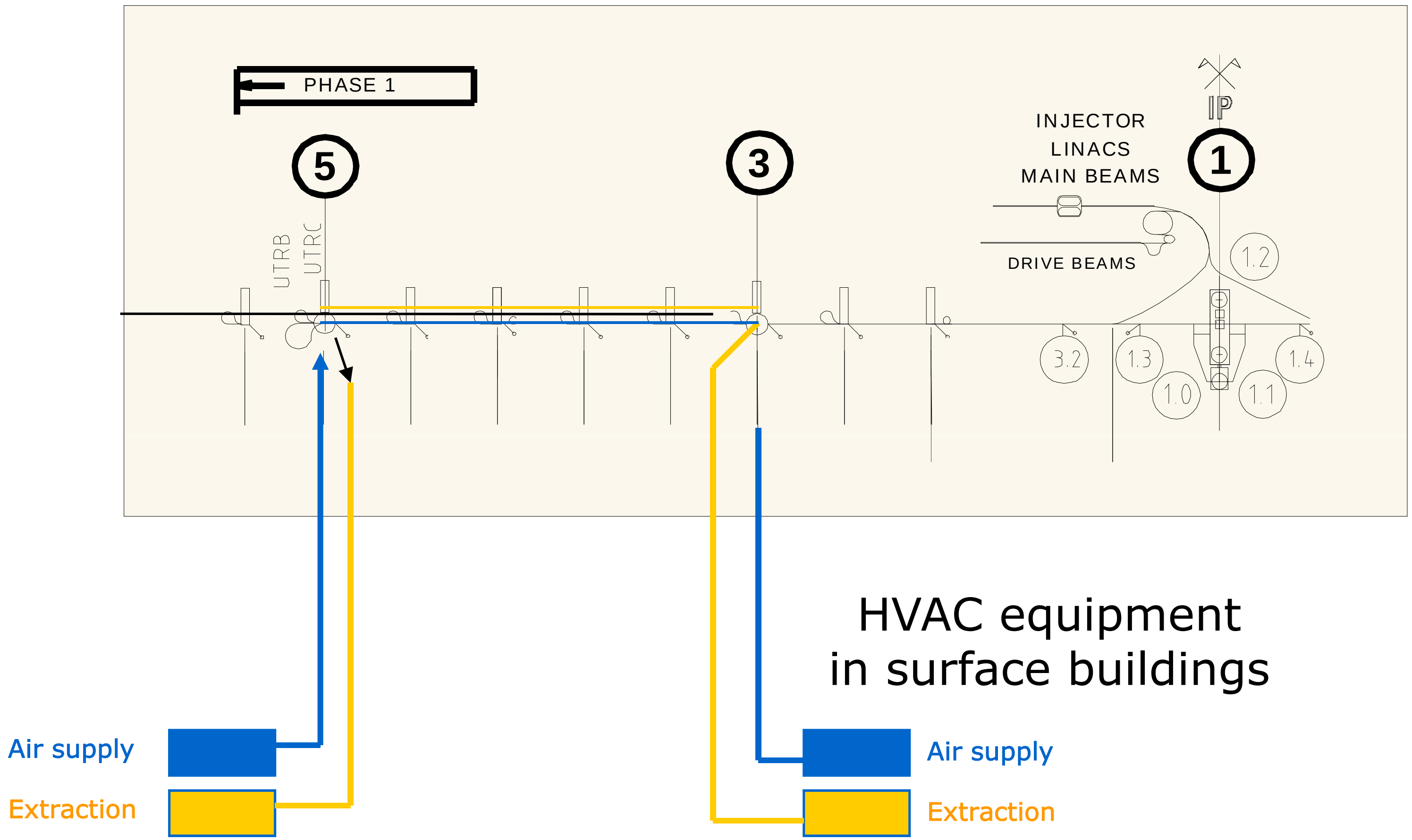


Basic data: Delta Temperature (Extraction – Supply) = 28 – 18 = 10°C

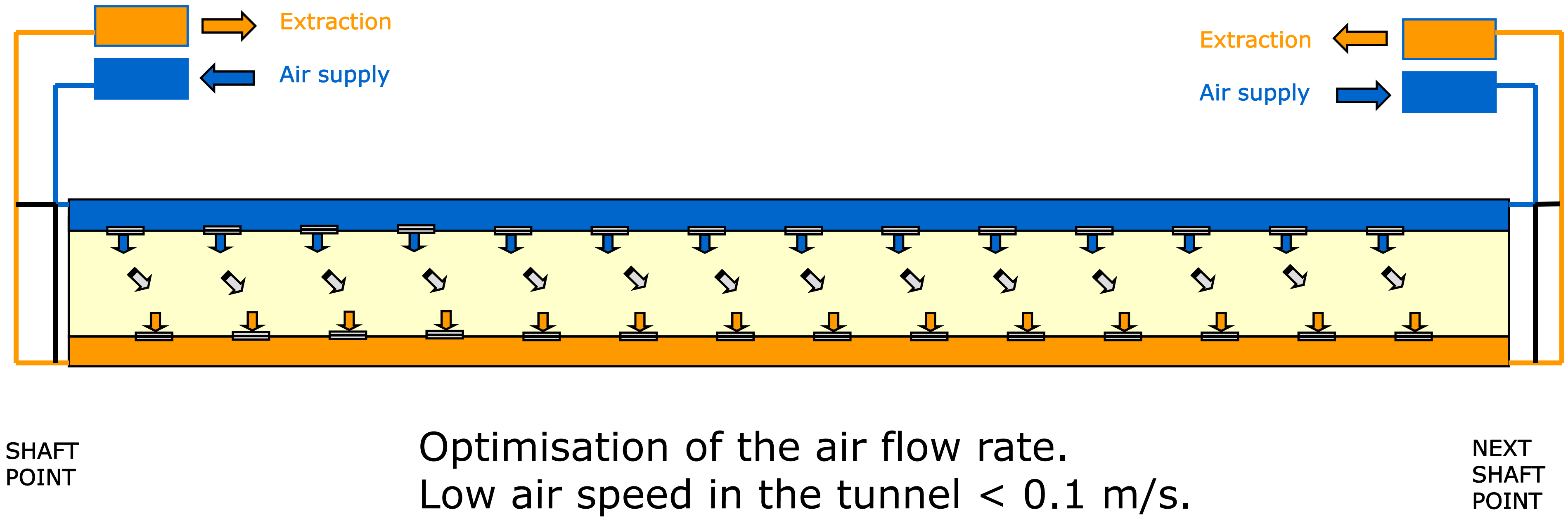
		Heat loads in the tunnel	Air flow rate	Air duct section	Air duct Diameter
Input data	DB sector	250 kW	75 000 m^3/h	1.73 m^2	1.48 m
	Intershafts	1250 kW	370 000 m^3/h	8.56 m^2	3.3 m
Proposal	Intershafts	500 kW	150 000 m^3/h	3.3 m^2	2 m

To be
Optimised …

Tunnel Air handling from the surface

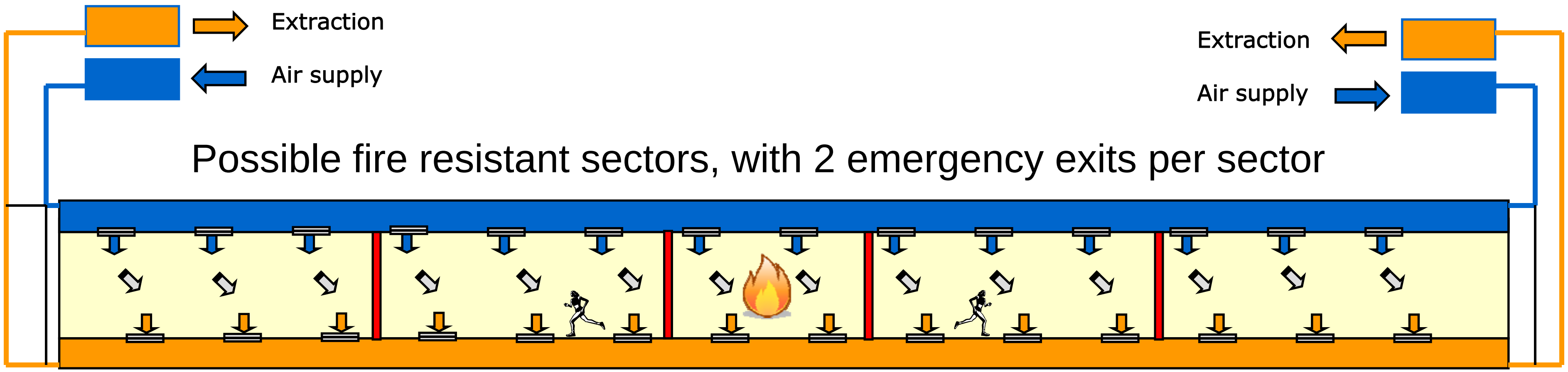


Semi transversal ventilation in tunnel



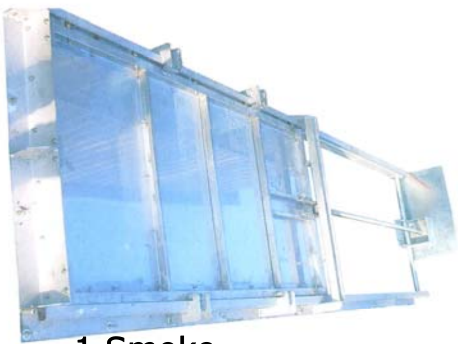
Optimisation of the air flow rate.
Low air speed in the tunnel < 0.1 m/s.
Optimisation of the temperature gradient.
Recycling of the tunnel air possible.
Reversible operation possible.
Energy recovery possible.

Semi transversal ventilation in tunnel



SHAFT POINT

NEXT SHAFT POINT

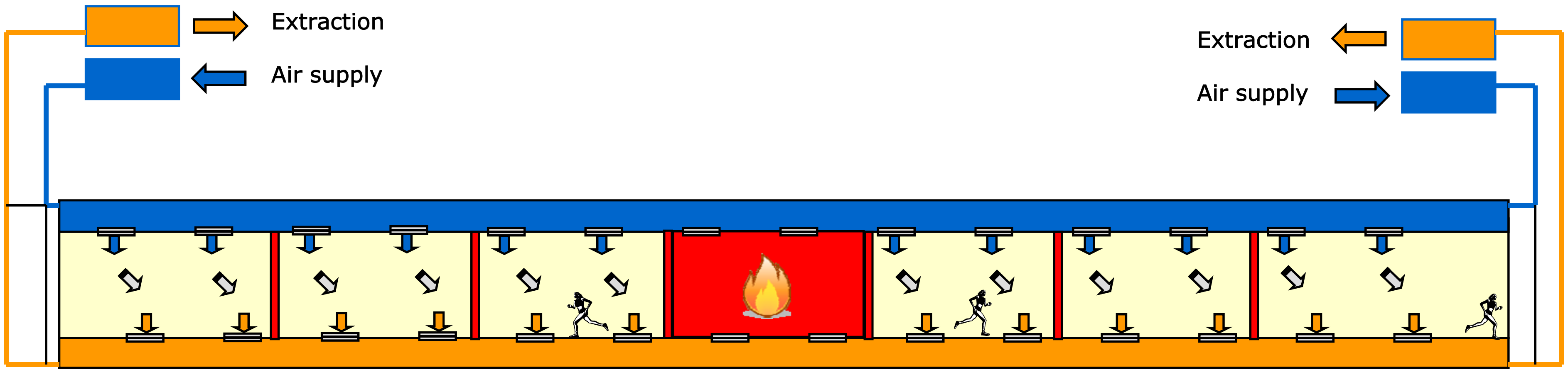


1 Smoke extraction trap per sector

Minimum maintenance
Sealed, modulated
Fire resistant
Compressed air control

1 supply and
1 extraction grilles
per 30 m

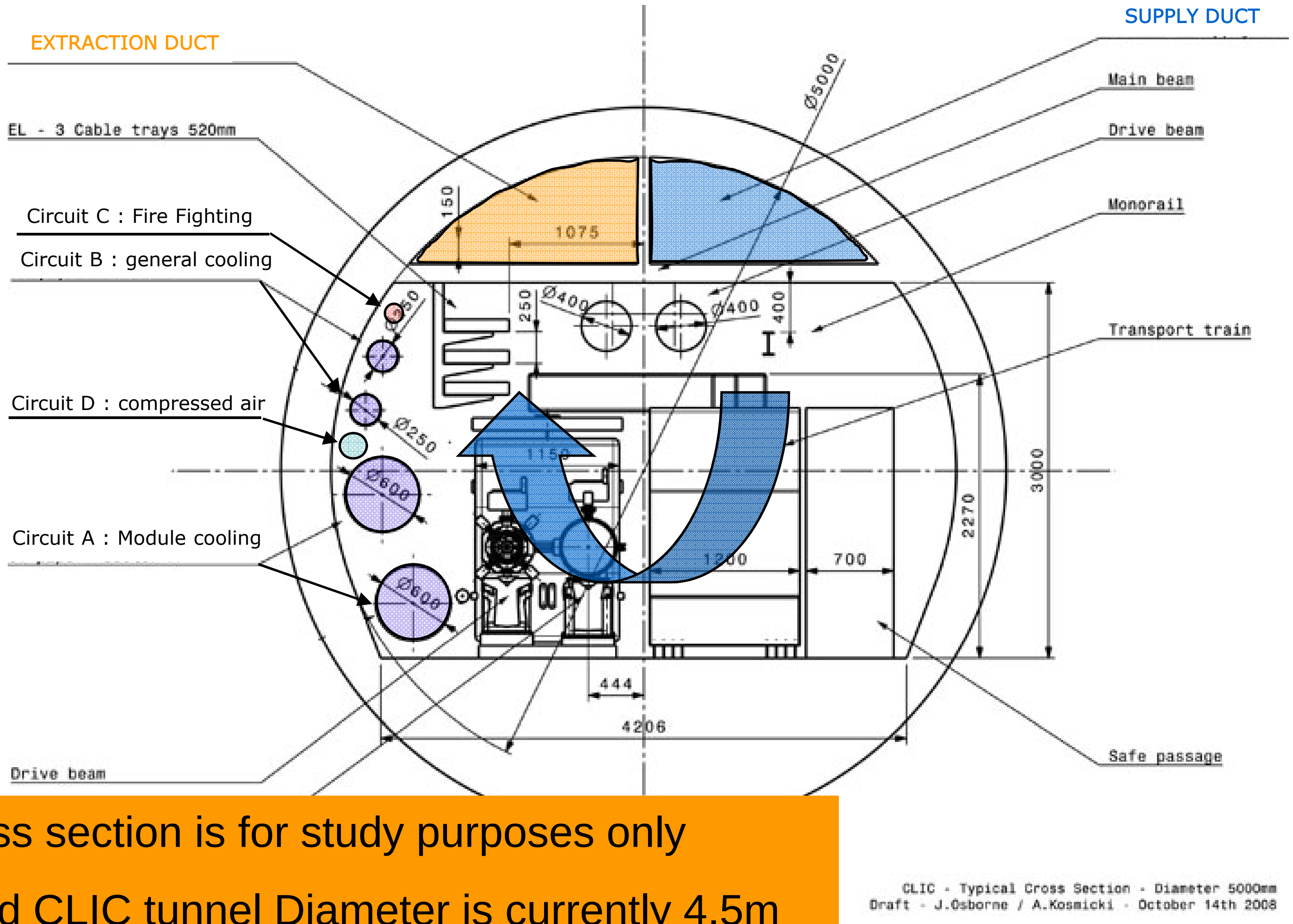
Safety considerations



SHAFT POINT

- Control of the pressure from both ends of a sector.
- Control of the pressure (overpressure or underpressure in each area).
- Fire detection per sector compatible to fire fighting via water mist.

Tunnel section

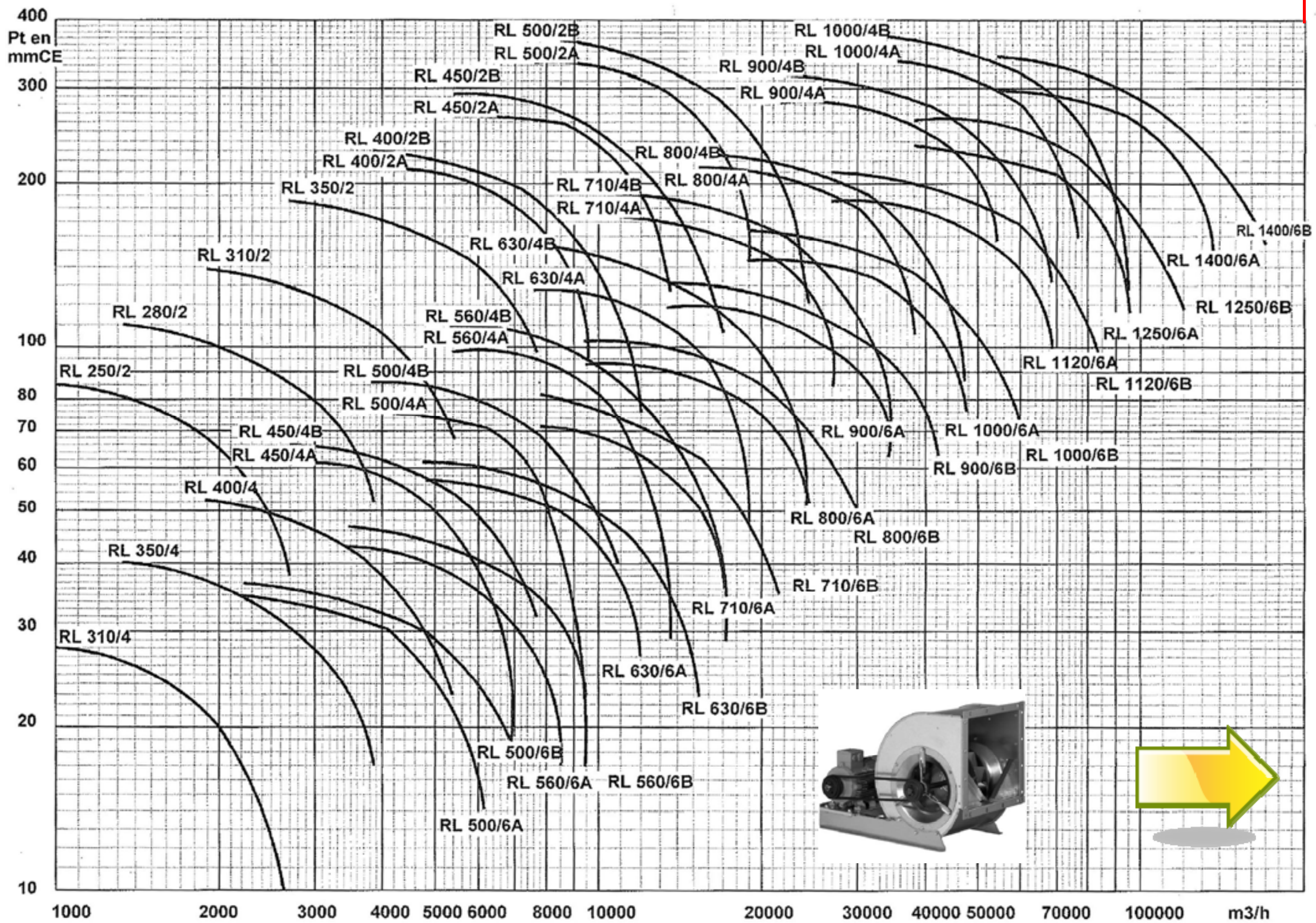


This cross section is for study purposes only

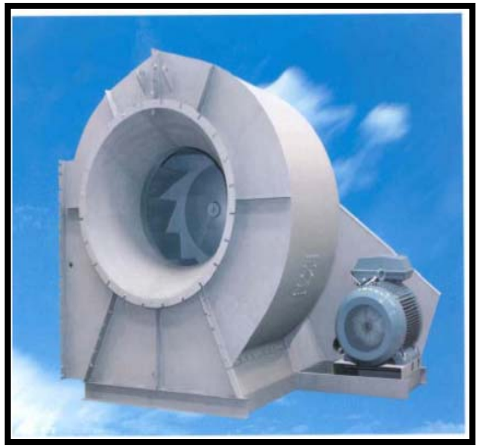
Approved CLIC tunnel Diameter is currently 4.5m

Equipment issues

Not standard industrial fans



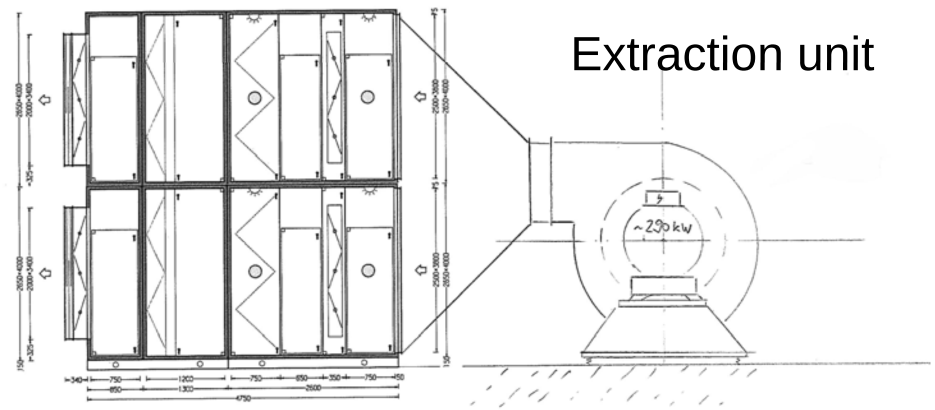
High pressure fans
Adapted products
Not standard equipment



Equipment issues

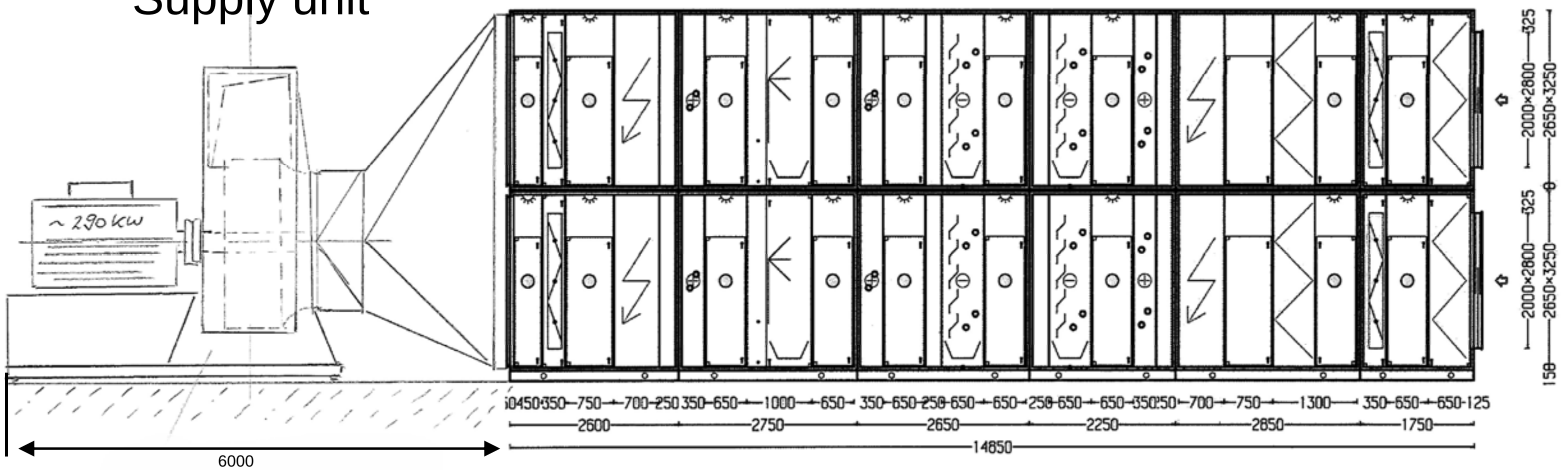
Special design

Fan in specific concrete section
Concrete air ducts
Direct driven fans (no belts)
Fan in specific concrete section
Concrete sound attenuation



Extraction unit

Supply unit



Perspectives

- Heat loads in tunnel air to optimize
- Heat loads in Exp. caverns, Klystrons to be defined?
- Radiation levels in the various areas to be defined
- Integration of ventilation ducts in the tunnel section to finalize

Cooling

- Water cooling requirements
- Fluid circuits
- Cooling production
- Main cooling station
- Tunnel section. Piping
- Equipment considerations
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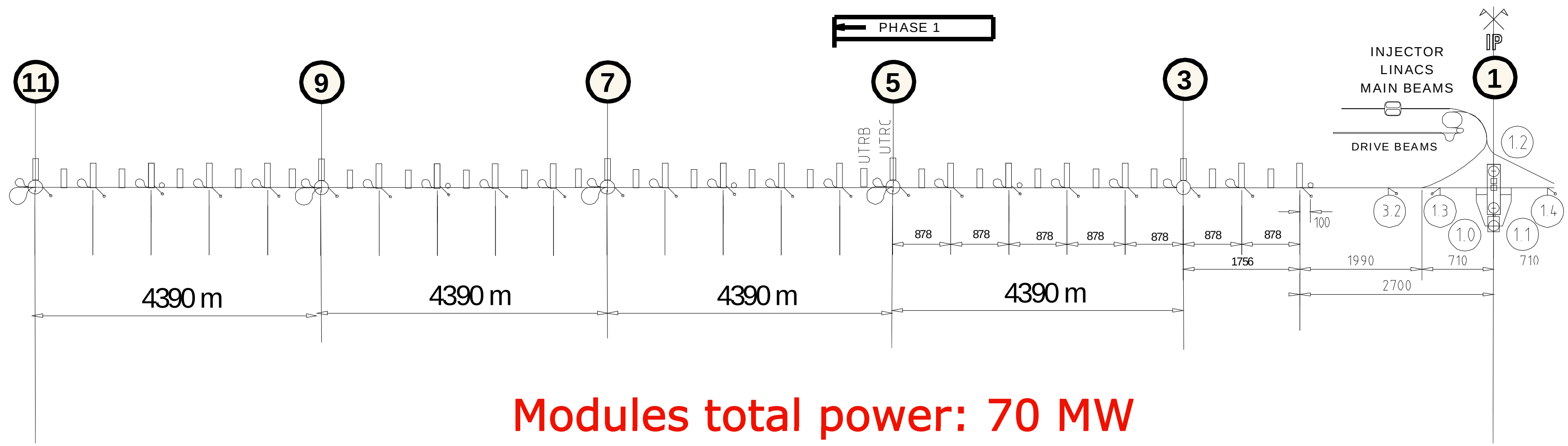
Water cooling requirements

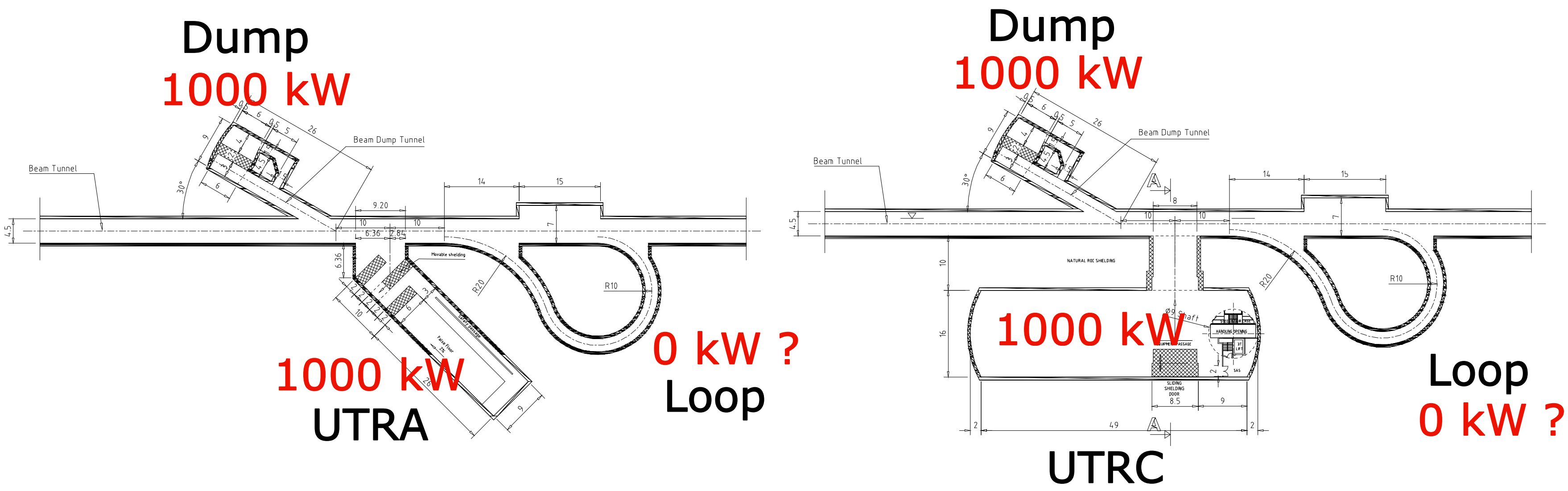
Modules cooling (circuit A)



Modules total power: 70 MW
Required flow-rate: 3215 m3/h
Delta temperature: 20 K
Temp. Supply: 25 °C

Water cooling requirements

General cooling (circuit B)

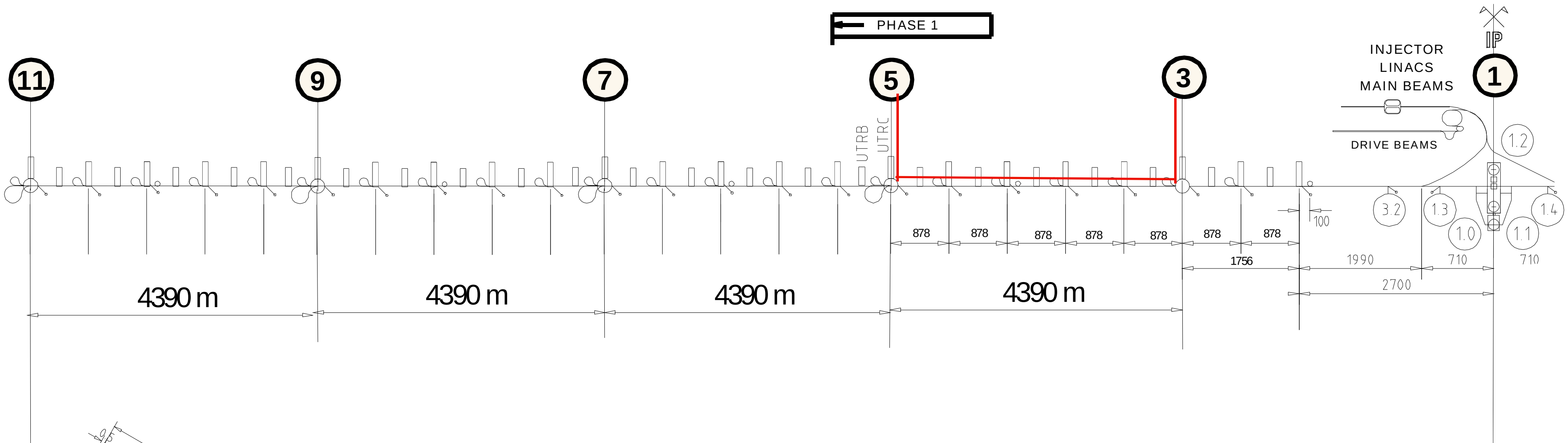


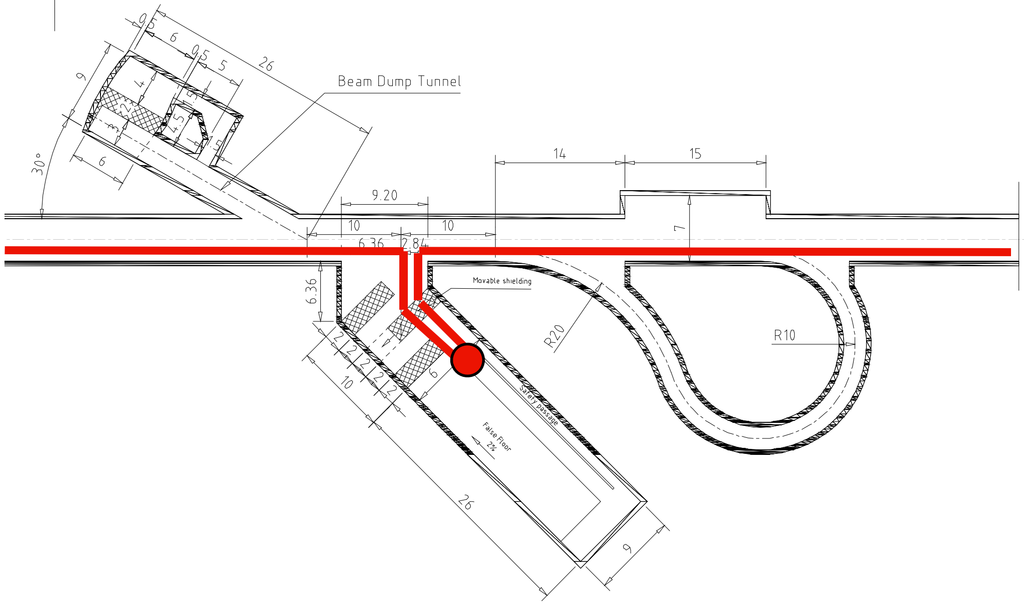
Modules total power: 15 MW
Required flow-rate: 1612 m3/h
Delta temperature: 8 K
Temp. Supply: 27 C

Fluid circuits per side

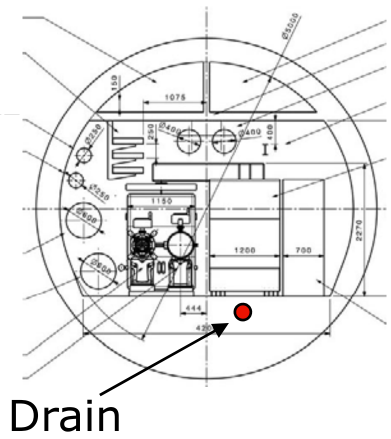
- CIRCUIT A : MODULES COOLING – 70 MW
  Demineralised water, 25/45°C, 2 pipes Ø600
  Accelerator structure, Loads, PETS, Quadripoles
- CIRCUIT B : GENERAL COOLING – 15 MW
  Demineralised water, 27/35°C, 2 pipes Ø300
  UTRA, UTRC, Loop, Vacuum, Beam Dump
- CIRCUIT C : FIRE FIGHTING - Water mist – Ø80
- CIRCUIT D : REGULATION
  Compressed Air – 760 m3/h, Ø150, 8 bars
  - For solids (dust): class 1 with max. 0.1 mg/m^3
  - For water : class 2 with -40°C dew point
  - For oil : class 1 with max. 0.01 mg/m^3

Raising circuits





Tunnel section

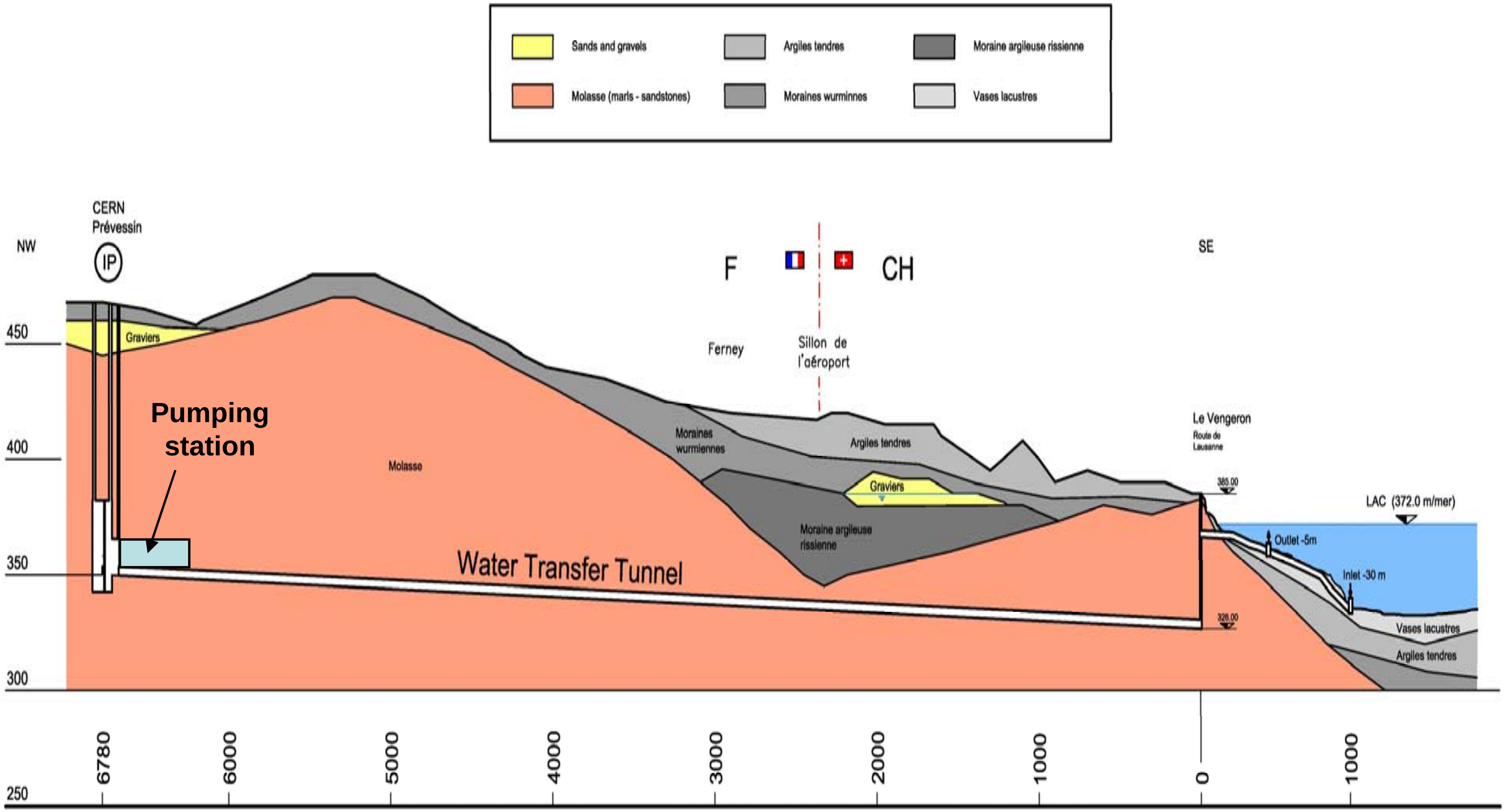


Raising pumps

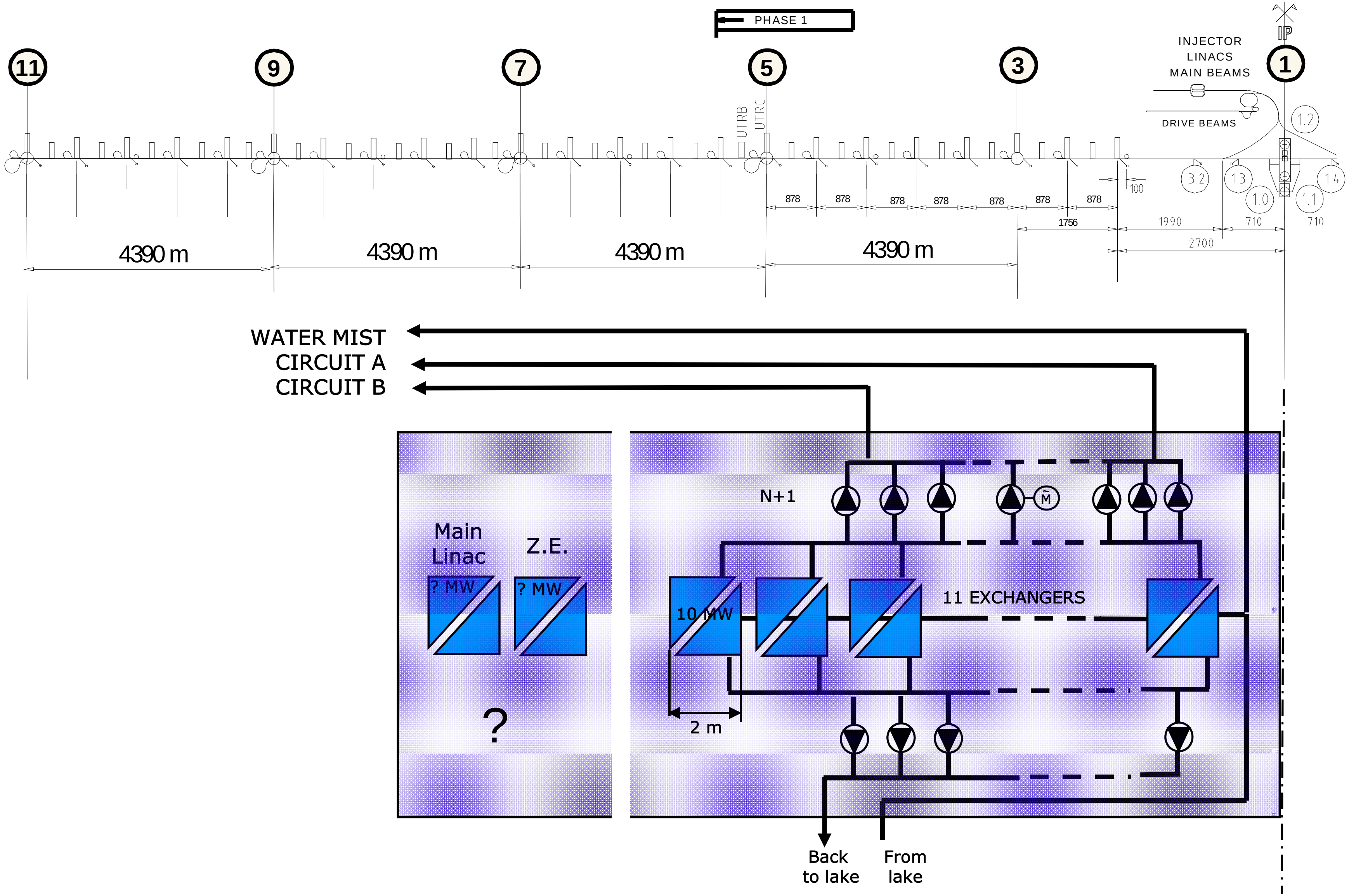
Cooling Production

Longitudinal section 1:25'000 / 2'500

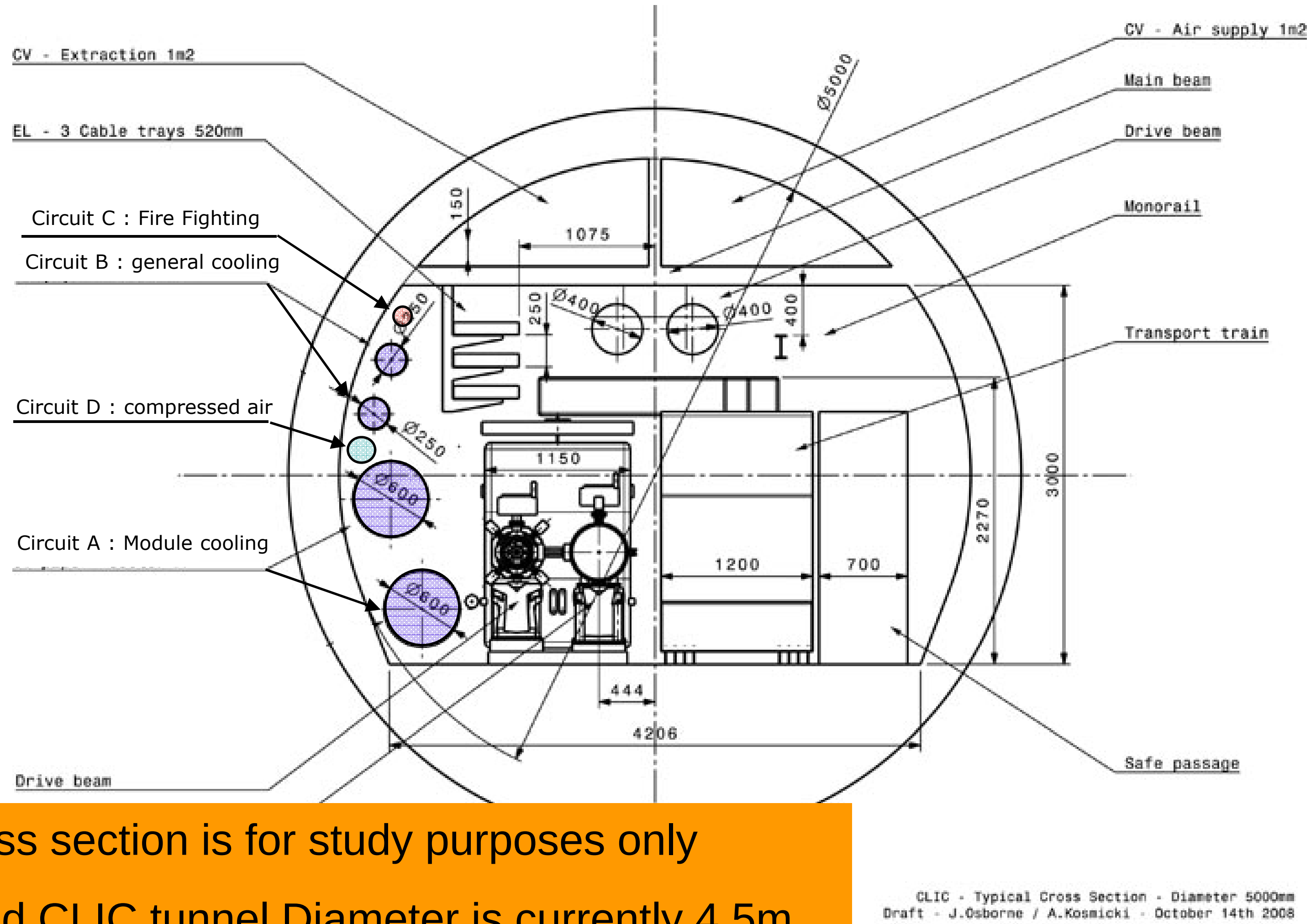
Water Transfer Tunnel



Main Cooling station



Tunnel section. Piping



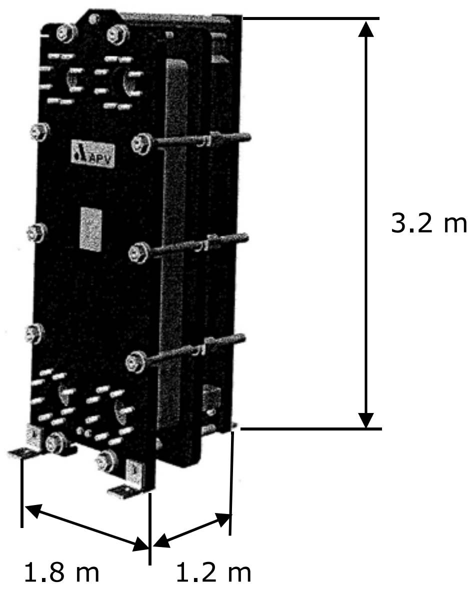
This cross section is for study purposes only

Approved CLIC tunnel Diameter is currently 4.5m

Equipment considerations

- Out of standard pipe diameters
- Special tooling, welding process
- On request manufacturing, PN an issue?
- Extra large heat exchangers

6 MW
Heat
Exchanger



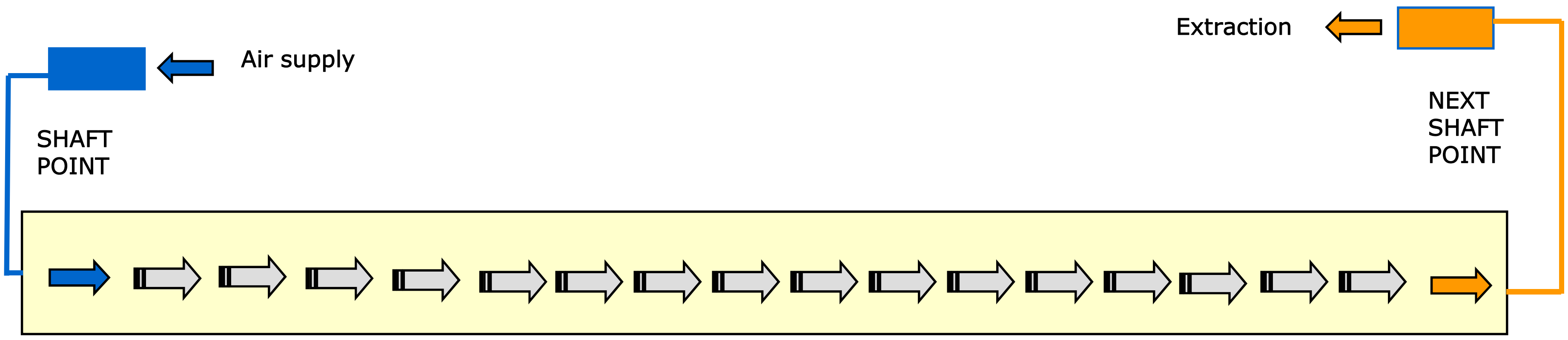
Missing items affecting main cooling station

- Cooling power for experimental cavern ?
- Cooling power for Main dumps
- HVAC and cooling for klystrons
- Confirmation about the rate air/water

Other items to be considered:

- Fire-fighting flow-rates
- Infiltration water, raising pumps, slopes

Longitudinal principle



Large air flow rate
High speed
Temperature gradient

Base:
150 000 m3/h
1250 kW
Delta T°C = 24 = (41-17)
Air speed = 2 m/s