Modification of the LHC Ventilation System

M. Nonis EN/CV

LHC Performance Workshop
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Task Force on Safety

Rec # 14: The Safety Task Force considers that the ventilation system is relevant for safety of personnel and thus recommends to set up a study of the LHC ventilation system with respect to monitoring and reliability of the system.

Contents

- Present situation with respect to possible referential and major issues raised
- Minor helium leak scenario
- Monitoring:
  - New sensors – overpressure/air speed/temperature
  - RP monitoring: Point 4 and Point 6
- Confinement:
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  - Overpressure tunnel – LHCb cavern, ALICE
  - TI2-TI8
- Reliability
- Fire safety
  - Extraction/supply units on safe network
- Consolidation issues
- Conclusions

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Referential

ISO 17873 (***Nuclear Facilities – Criteria for the design and operation for ventilation systems nuclea****r installations other than nuclear reactors*) in force since 2007, not applied as no changes to the existing LEP system foreseen by LHC Project.

- The main purpose of the ventilation system is to improve the safety of the workers, the public and the environment by keeping them free of contamination.
- Definition of functions linked to safety
  - Confinement (dynamic) to counteract any defects in the static confinement and limit the egress of contaminants,
  - Purification by conveying collected gases, dust, aerosols and volatiles towards collection points (filters, traps, etc.),
  - Monitoring of the installation, by organising air flows to allow meaningful measurements and detect spread of activated components during normal and abnormal conditions,
  - Cleaning/purging of the atmosphere by renewing the volumes of air (Industrial hygiene),
  - Conditioning of the atmosphere to obtain optimum functioning of machines.

- The HVAC system ensures the safety functions are maintained in normal O&M conditions and may ensure some functions during abnormal or accidental situations, based upon a safety assessment of the installation.

[ref. *Inigo Golfin – LHC performance workshop - Chamonix 2009*]

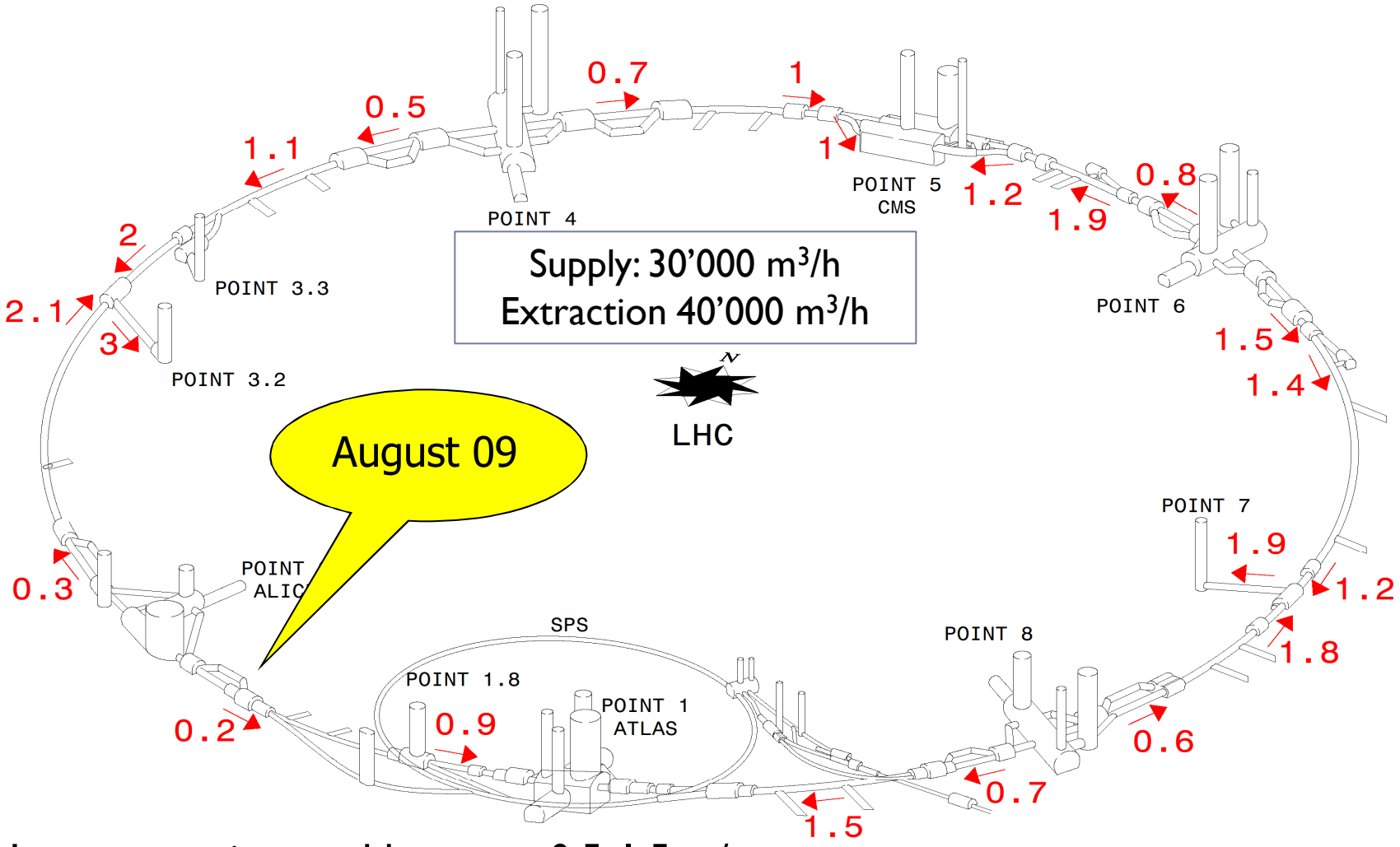
ISO 17873 Guidelines

- Confinement:
  - Leaktight and static confinement recommended.
  - Keep extraction networks separated: OK
- Purification:
  - Filter air before release (appropriate filters class) OK
  - Air renewal: 1 to 2 vol/hour: (LHC: ~1) OK
- Monitoring
  - Monitor ventilation parameters: next shutdown
- Reliability
  - Ensure fonctionnalities in degradated mode: tests ongoing
  - Avoid boosters to compensate pressure drops.
  - Periodic test: 1 per year - to be implemented
  - Redundancy of systems: few cases to solve
  - Fire dampers manually operated if needed.
  - Extraction from activated areas priority; if stop supply should halt.
  - No single point of failure: exist but experience ok

Major Issues

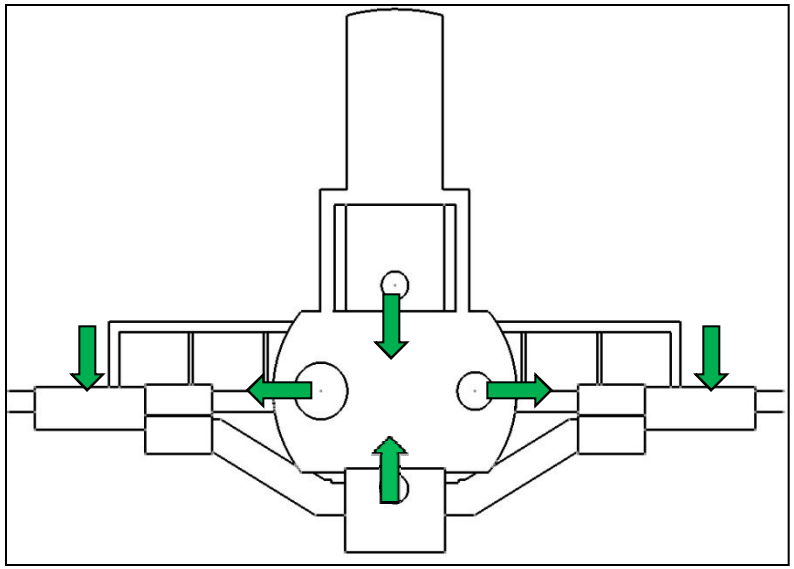
- Ensure fresh air supply as much as possible.
- Respect of sectorisations, avoid mixing of air.
- Stability of overpressures.
- Availability of information on ventilation configuration and overpressure to decide the most appropriate procedure to enter underground areas.
- Enable RP monitoring of air at extraction points.
- Smoke extraction in case of power cut.
- Evacuate controlled helium leak (1 kg/s for 25 minutes).

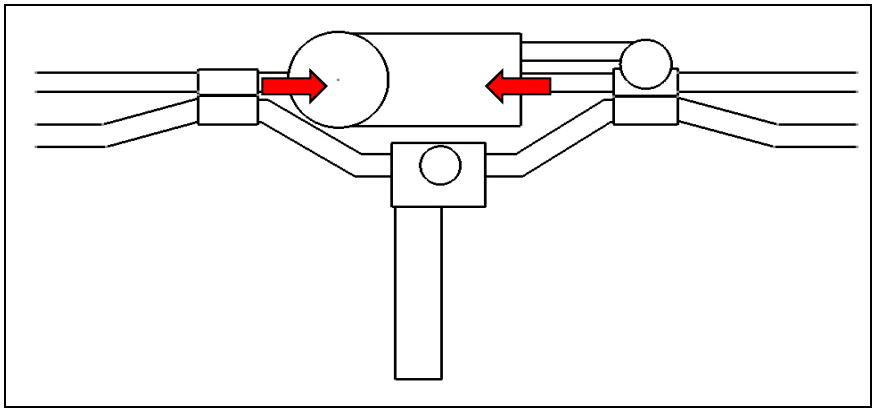
Operating Conditions Run 2009-2010: Air Speed

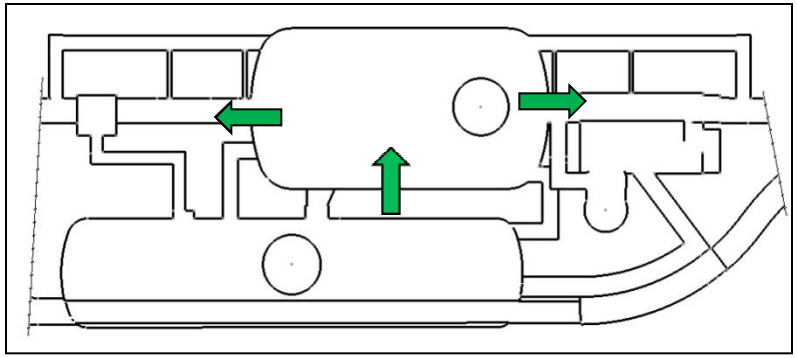


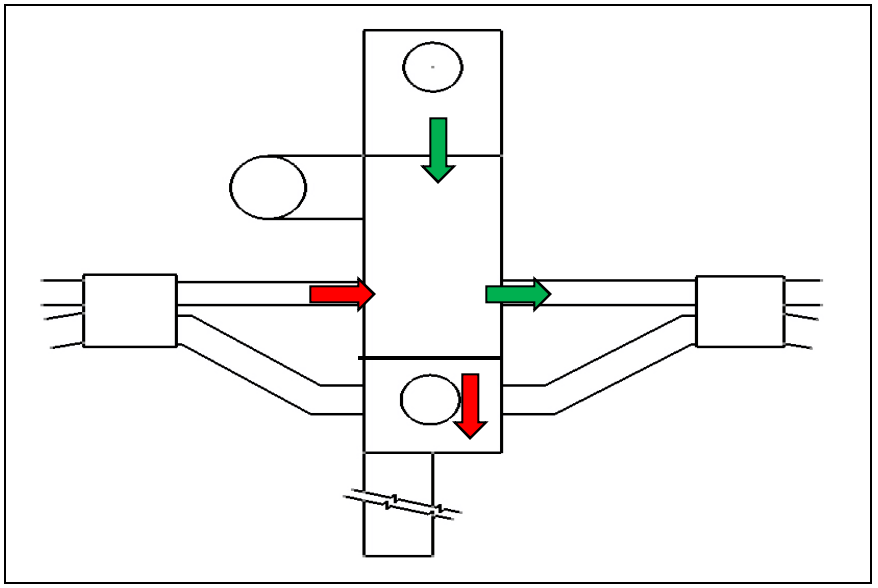
Long term: air speed between 0.5-1.5 m/s

Operating Conditions Run 2009-2010: Overpressures



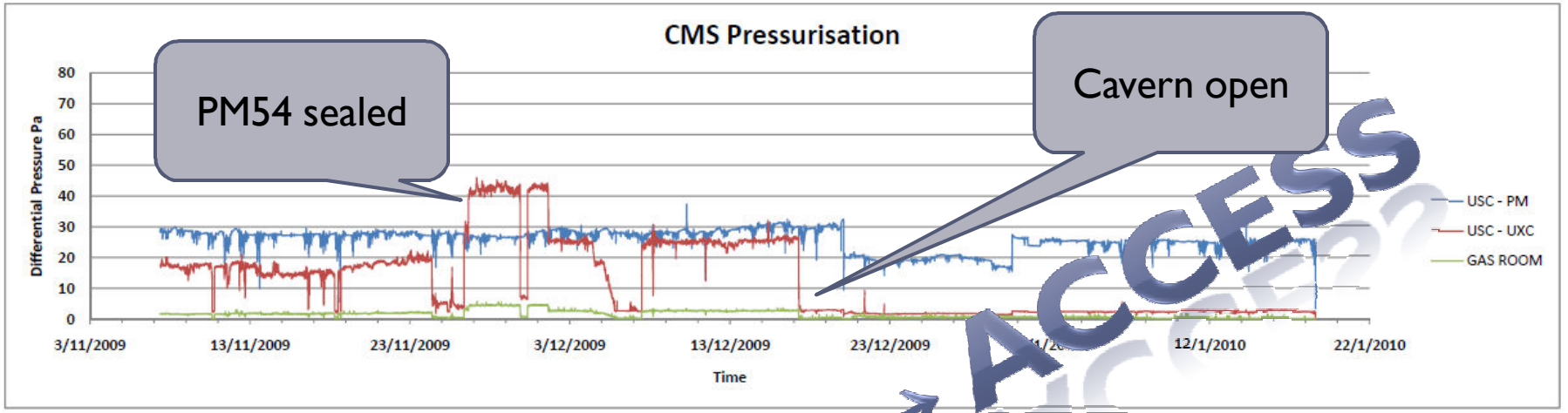


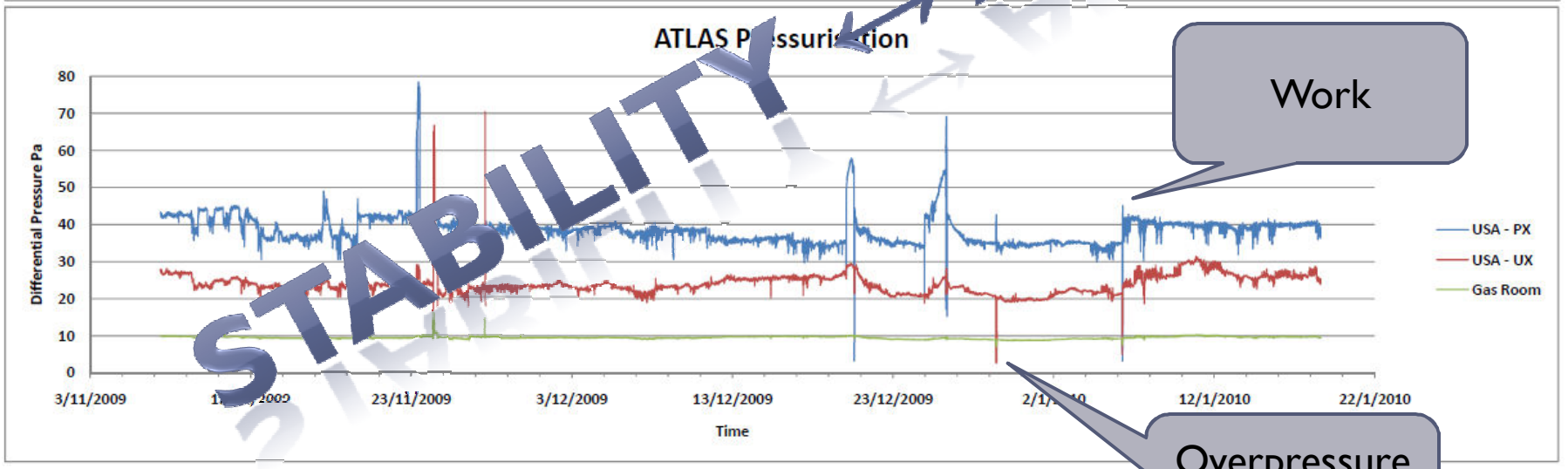




Shaft pressurisation: ok

Operating Conditions Run 2009-2010: Stability of Conditions





STABILITY ↔ ACCESS

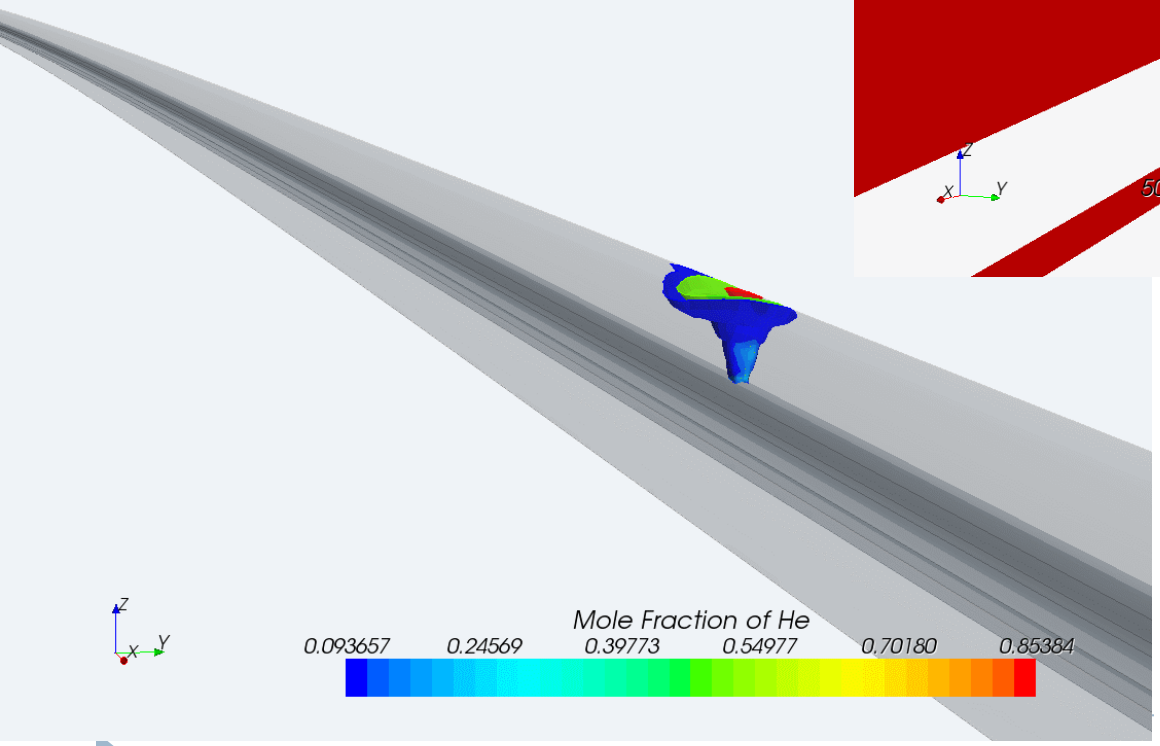
Overpressure test

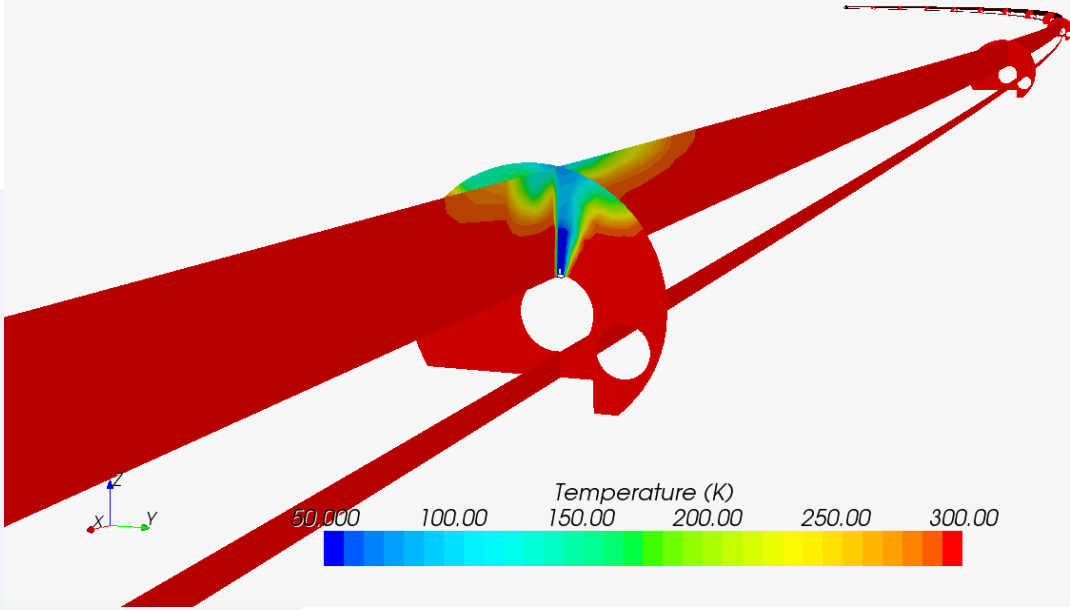
Controlled He Leak

Minimum high for 10% He concentration (about 0°C):

- 1.20m in the 10m far from the leak
- 1.90m in the rest of the tunnel

He mole fraction plotted on iso-surface for 100k, 180k, 273K corresponding to a He concentration to about 90%, 50% and 10% respectively.





Minimum height for 10°C:

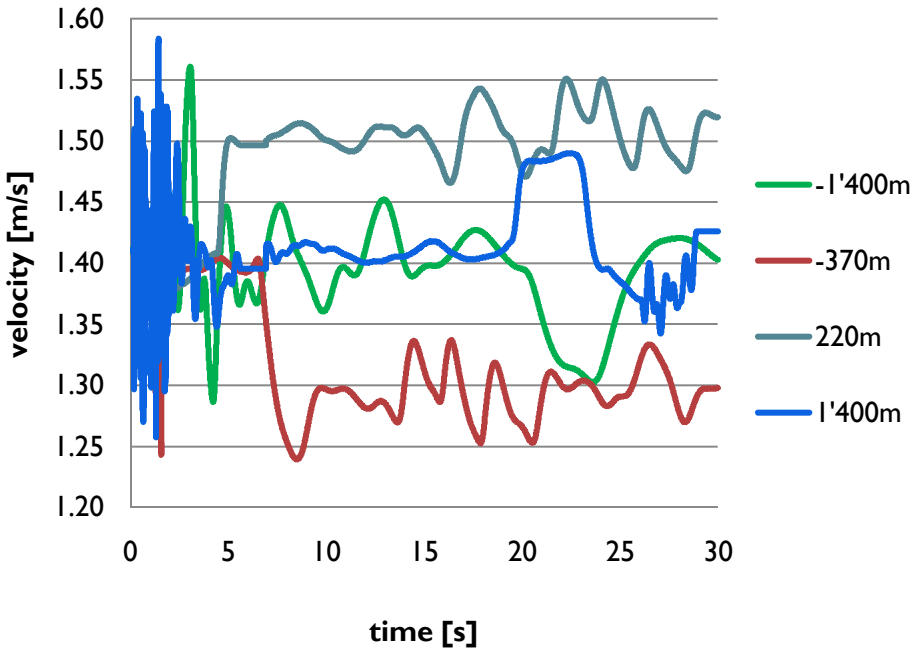
- 1.10m in the 5m far from the leak
- 1.70m in the rest of the tunnel

To validate experimentally

Animations running in real time

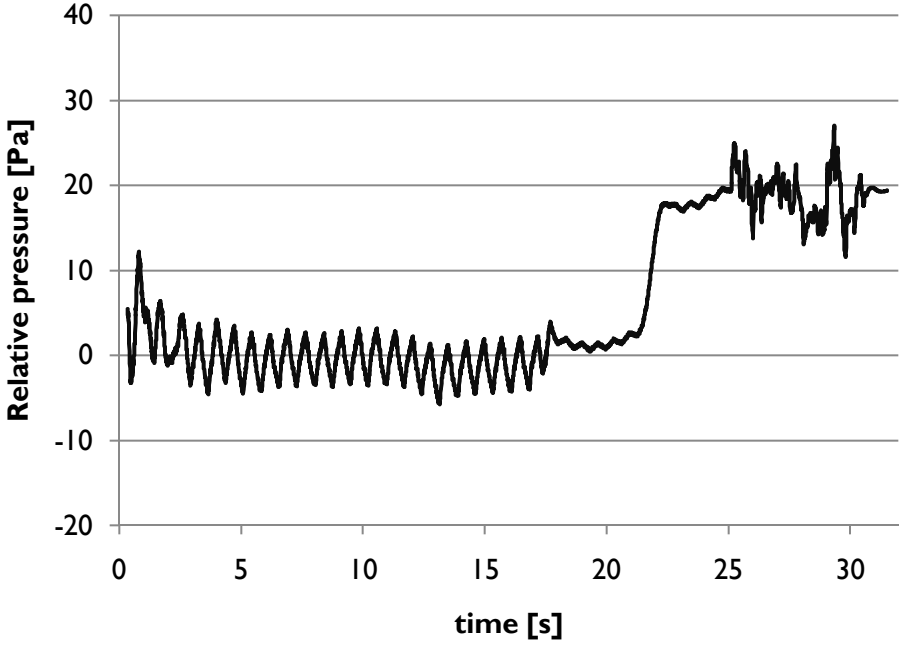
Controlled Helium Leak: 1 kg/s, 50 K

He-Air mixture Speed



- Air velocity is 1.4m/s
- Reduction/increase of the velocity of about 0.1 m/s

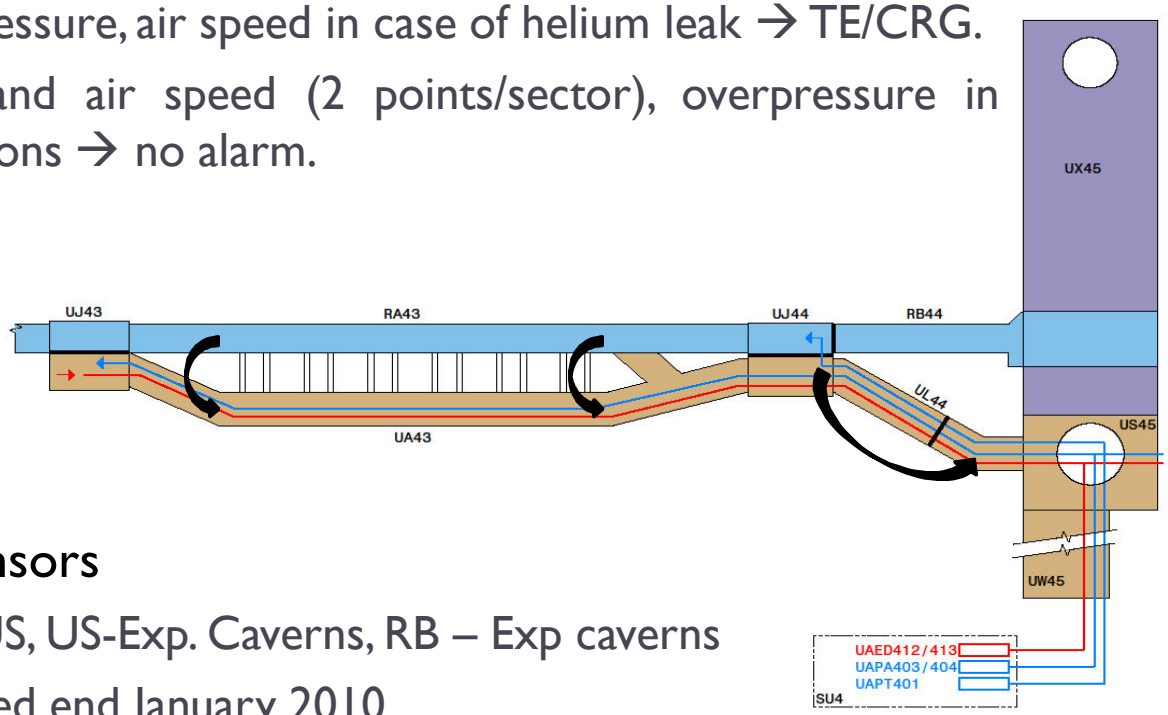
Relative pressure at the end of the tunnel



- Increases of pressure reaches the end of the tunnel in 22 seconds with an variation of 20Pa.
- Increase of pressure in the tunnel propagates at 80 m/s.
- Second step of pressure increase when the pressure "wave" rebounds at the end of the tunnel which travels back at the same speed.

New sensors in tunnel

- Install new sensors to monitor air conditions in the tunnel:
  - Temperature, pressure, air speed in case of helium leak → TE/CRG.
  - Temperature and air speed (2 points/sector), overpressure in standard conditions → no alarm.



- Overpressure sensors
  - UA-RA (2), UJ-US, US-Exp. Caverns, RB – Exp caverns
  - Point 8 completed end January 2010
  - Schedule: 1 week /Point, next shutdown
  - Cost: ~ 30 kCHF/point = 200 kCHF

(N.B: temperatures in front of RE and RR already available on CV monitoring system)

RP Monitoring

- Reinstallation of extraction units from PX64 and PX46
- One single exhaust point for RP monitoring
- Reduce mixing of air from RF into cavern
- Completed on first months of 2010

Confined Ventilation Sectors

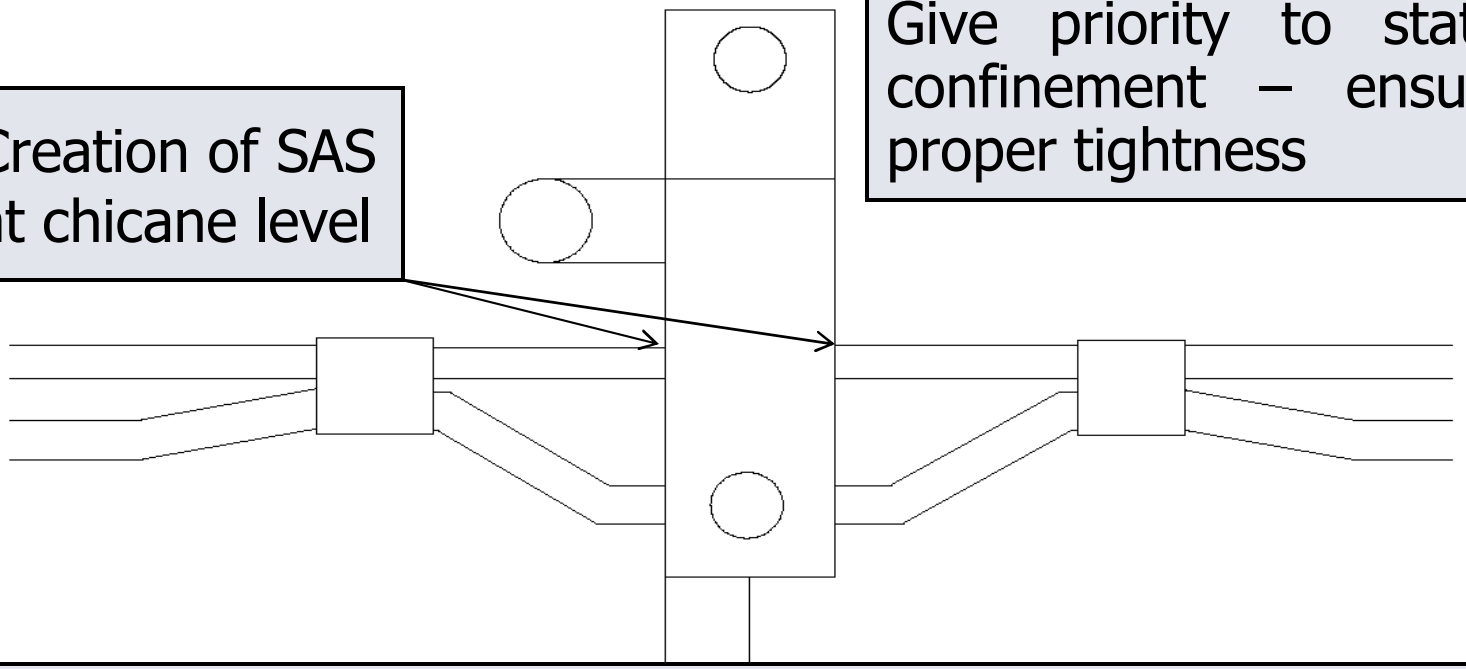
	Run 2009-2010	Long term
RA – UA	No	Static + dynamic
UA – US	No	Yes, static
Exp cavern – Service cavern	Static + dynamic	Static + dynamic
Shafts, pressurised area	Dynamic	Dynamic
Collimators Pt 3 and 7	No	T.b.c.
UJ76 – TZ76	Static	Static
UX45 – RBX	No	No *
UX65 – RBX	No	No *

* Not critical for RP

Confinement UA-RA

- All drills that can't be sealed shall be ventilated by a dedicated fan – not redundant.
- Air taken from UA, not fresh air.
- Each configuration to be specifically studied according to geometry and high pressure drop in the drill.
- If fire dampers should be foreseen – affect performances.

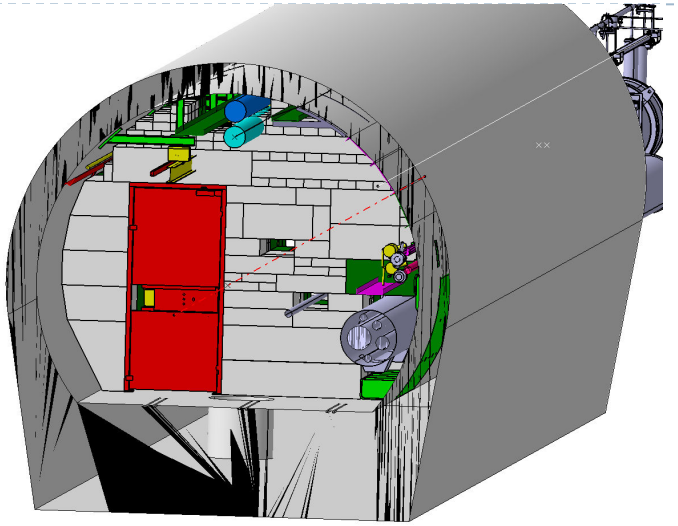
LHCb – Tunnel Overpressure



Two speed fan (redundant):
500 – 1000 m^3/h - DN 300 duct

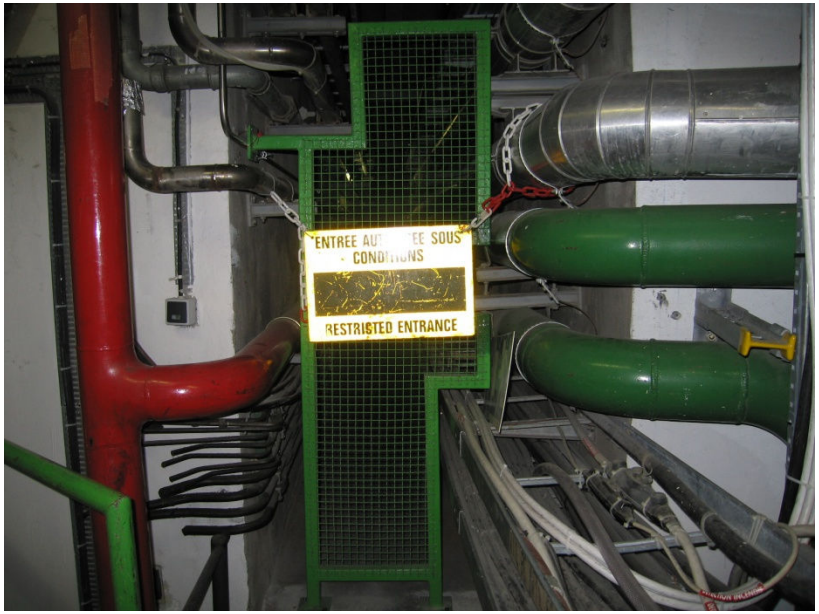
Overpressure US85-UX85 possible only if increase extraction from Experimental cavern

Confinement RB86,RB84



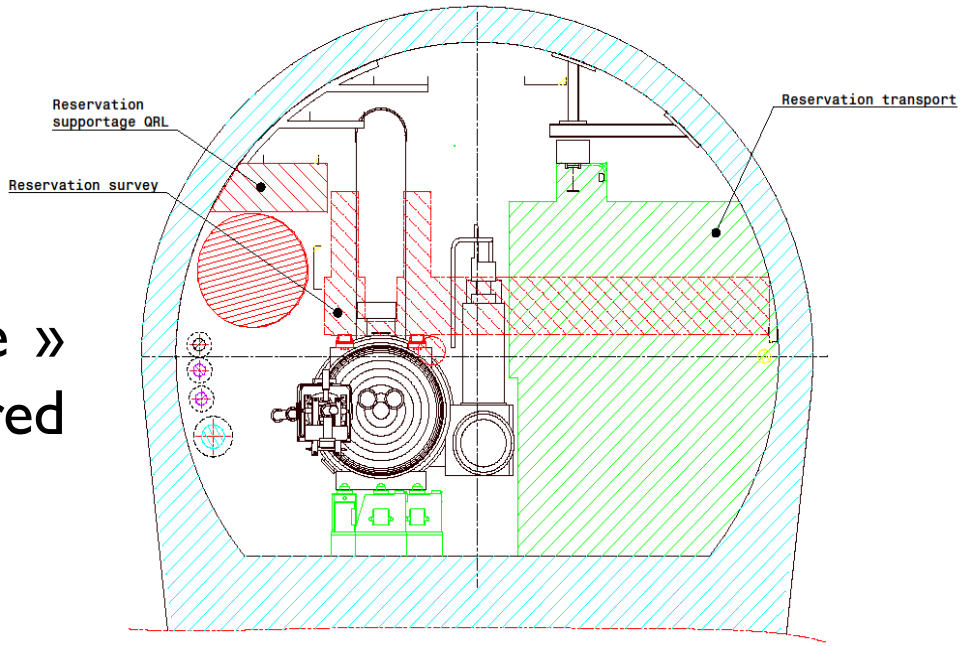
Confinement US areas

- Pressure in USs linked to external conditions (PM shaft open)
- Problematic in even points (UA are supplied with fresh air)
- Doors in ULs have to be airtight.
- Ensure air tightness between US25 and UX25



Static Confinement TI2 – TI8

Confinement TI2 and TI8 wrt to the tunnel shall require the installation of a DN750 duct from UJ24 to UJ22 and from UJ86 to UJ88 to ensure the supply of fresh air and the use of redundant booster fans to compensate the pressure drop.



The « emergency mode » (45'000 m3/h) not covered - DN1000 required.

Redundancies

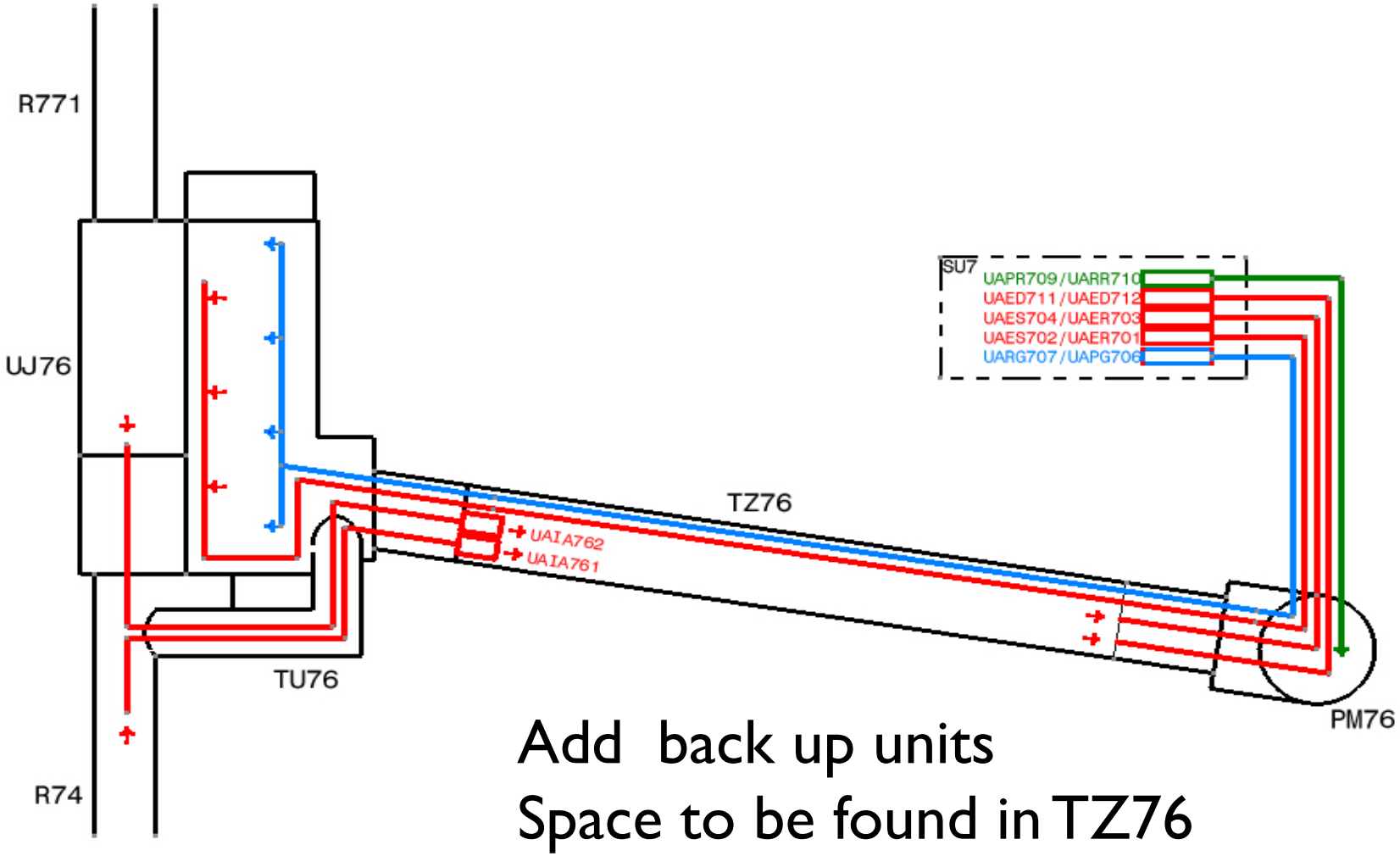
All AHU are backed up by a redundant unit with the following exceptions:

- Extraction from RF area in UX45 into shaft.
- Point 7: boosters in tunnel.

Breakdown : < 1 year

- Point 3: boosters in tunnel - flow rate corresponding to TA mode (20'000 m3/h).
- Areas in PX24: (in case of simultaneous breakdown, lower flow rate guaranteed).
- PM65 and PZ65 (in case of simultaneous breakdown, lower flow rate guaranteed).
- Supply tunnel: overall flow rate 38% lower in TNA mode.

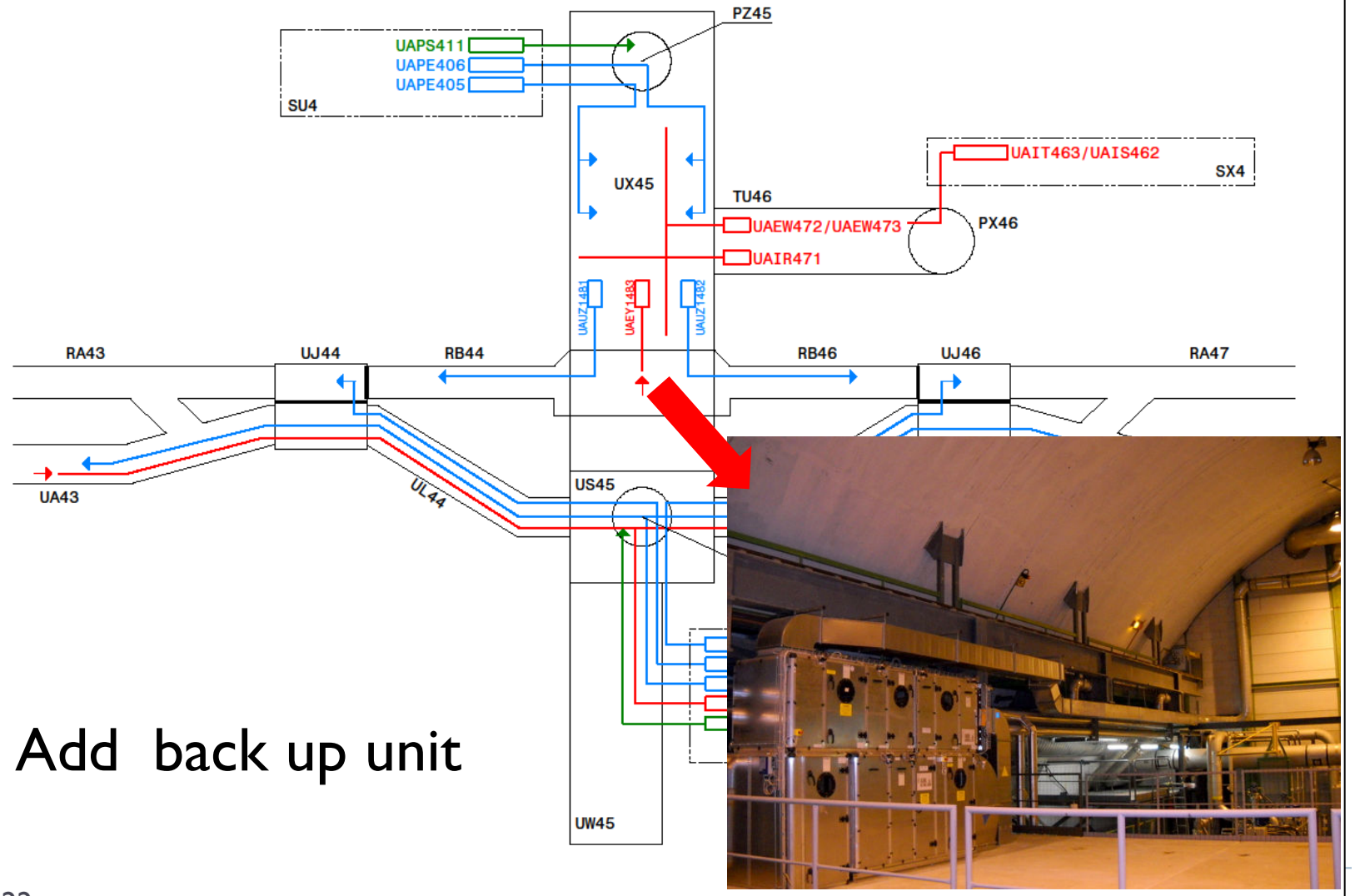
Missing Redundancies: Booster Pt 7



Add back up units

Space to be found in TZ76

Missing Redundancies UX45



Add back up unit

Fire Safety

- Ventilation can ensure confinement of pressurized areas if doors kept closed (contact alarms)
- Action to be taken decided on site by Fire Brigade after assessment of the situation.
- Extraction system designed for **COLD** smoke extraction (without filtering): not possible to change unless changing the whole plant, incl. work in PM shafts!
- If cold smoke filtering required → major CE and CV work (housing, automatic change over, fire proof).

	Alarm Fire	**Alarm Gas**	**Power supply**
Tunnel	AHU stopped	Stop	General services
Experiments	AHU stopped	ATLAS, CMS run	Secure network

Tunnel Units on Secure Network

- In case of power cut on surface, no ventilation of the corresponding tunnel sectors and UA is possible.
- Priority on extraction (Pt 7, 3 - booster + AHU) than on supply.
- EL work:
  - Safe power not available in Pt 3, 7 and all even Points
  - New safe network to install
  - EL Cost: 4 MCHF * extraction + 6 MCHF * supply

(* civil engineering costs not included)

- Supply units at present on secure network (cost for pre-heating coils vs need of purge): investigation ongoing to assess the risk

Consolidation Plan

- Installations date mostly to LEP construction period.
- Although correctly performing, part of the LHC ventilation system shall need refurbishment or consolidation work in next years.
- The following issues are part of EN/CV consolidation program [ref. *Mid-term consolidation plan for the cooling and ventilation facilities, 2010-2017* – August 2009]

	Priority	**Risk score**		**Amount [MCHF]**	**Planning**
		Before	After		
Absolute filters (tbc by RP)	*(H)*	*6*	*3*	*0.8*	*2011-2012*
Safety features	H	9	2	1	2010-2012
Supply air plenum	M	6	3	0.6	2012-2015
Thyristors replacement	H	6	3	0.8	2011-2013
Instrumentation replacement	M	9	3	0.5	2011-2014
Vibr. analysis AHU	M	9	3	0.8	2013-2017

N.B.: CE, EL etc. costs not included

Conclusions

- Situation already quite satisfactory.
- Not possible (realistic or costly) to fully comply to ISO17873.
- Implementation of new functionalities are not technically optimal, more a compromise.
- Decisions have to be taken on the policy to follow on some issues (AHU on secure network) or on technical solutions to implement (UA-RA, TI2, TI8…).
- Most modifications completed in short/medium term, according to resources allocated.

Thank you for your attention