Health, safety and environment

Ralf Trant on behalf of the HSE team

HSE
Occupational Health & Safety
and Environmental Protection Unit

SAFETY POLICY @ CERN

The objectives of the Organization's Safety Policy are:

- to ensure the best possible protection in health and safety matters of all persons, independently of their status, participating in the Organization's activities or present on its site, as well as of the population living in the vicinity of its installations;
- to limit the impact of the Organization's activities on the environment, and
- to guarantee the use of best practice in matters of Safety.

Safety covers occupational health and safety, including radiation protection, the protection of the environment and the safe operation of CERN's Installations, including radiation safety.

Safety is a priority of CERN's general policy.

SAFETY REGULATORY CONTEXT

- FCC premises and infrastructures will be mainly located outside todays CERN domain: under which conventions/agreements all aspects of Safety will be treated?

- The overall Safety regulatory context for the FCC life cycle shall be defined early enough, ideally before the start of the design phase.

- All Safety authorities/entities and type/scope of relations shall be defined as early as possible.
  - This has a major impact on Safety studies required and the transparency process to be implemented.
  - Tripartite (CH-F-CERN) approaches shall be privileged as much as possible.
  - Early and regular communication on FCC Safety aspects is essential

RISK MANAGEMENT

$$R_D \overset{*}{\propto} \frac{n \times t}{Pv} \times \frac{D}{Pc} \rightarrow 0$$

- ***n**umber of people exposed to **D**anger* → n
- *exposure **t**ime* → t
- ***D**anger* → D
- ***P**re**v**entive measures* → Pv
- ***P**rote**c**tive measures* → Pc

✓ ***n*** and ***t*** shall be kept to the very minimum, ideally 0 if possible

✓ ***Pv*** and ***Pc*** shall be maximized *“at a reasonable economical cost”*

**** AFNOR : Maîtrise des risques – concepts fondamentaux***

Main Safety Domains

Air management	
Civil Engineering works	
Cryogenic Safety ***(incl. ODH)***	
Environmental Protection	
Fire Safety ***(incl. egress)***	
Radiation Protection	
Radiation Safety	
Workplace Safety	
Worksite Safety	

Radiation Protection – *Legislation and Parameters*

- Anticipate changes in legislation
  - Adopt most restrictive limits early on
  - Participation in international and national commissions giving recommendations
  - Particularities of high-energy accelerators

- Implement optimization (“ALARA”) from the concept phase onwards
  - Off-site releases
  - Handling of activated components
  - Minimization of radioactive waste
  - Adapt degree of conservatism (“safety margin”) to uncertainties in estimates

- Establish and fix design parameters early on
  - Maximum beam intensities and luminosities
  - Instantaneous and annual beam losses
  - Overall layout *(don’t change location of collimation area in the last moment!)*

Radiation Protection – *Research and Development*

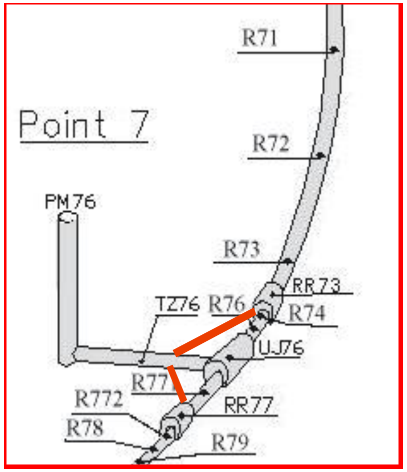
- Model development and benchmarking
  - ➢ The more accurate the model the lower the safety margins *(and costs!)*
  - ➢ Predictions for energies where no or little experimental data exist
  - ➢ Benchmark with experimental data to proof accuracy and facilitate approval process of authorities

- Generalized tools for repetitive assessments
  - ➢ Material optimization (ActiWiz code)
  - ➢ Radioactive waste assessments (Jeremy code)
  - ➢ Simulation of interventions in radioactive areas

- Instrumentation
  - ➢ Adapt to expected radiation fields
  - ➢ Consider and anticipate changes in legislation, *e.g., activation limits*
  - ➢ Develop methods to increase operational efficiency, *e.g., for material characterization or transport*

Radiation Protection – *Optimization of Infrastructure*

- Avoid /minimize access
- Fast and optimized access
  - Fast transport of personnel *(e.g. trains)*
  - Access zones and permissions according to risks
  - Parallel / bypass galleries at radioactive areas *(e.g., CNGS/TSG4, LHC/UA)*
  - External beam dump caverns *(as for the LHC)*



- Minimize transport
  - Local / underground radioactive workshops *(e.g., SPS/BA5)*
  - Local / underground intermediate radioactive storage

- Remote transport and inspections
  - Self-guided/remote transport of components/material
  - Tele-manipulation systems (e.g. change of an electronic card)
  - Remote inspections and surveys *(e.g., 'TIM' train)*
  - "Fast" transport of personnel *(e.g. trains)*

Radiation Protection – *Optimization of Ventilation*

- Releases
  - Avoid /minimize releases
  - Location of release points outside densely populated areas

- Ventilation mode
  - Closed circuit during operation to reduce release of short-lived activity
  - Flush with fresh air before access

- Infrastructure
  - Containment of air: static and/or dynamic, pressure cascade
  - “Longitudinal” compartmentalization: separate radioactive areas, modular access
  - Dehumidification of air at surface to avoid condensation of activated air
  - Drains away from loss points to minimize direct activation

Radiation Protection – *Optimization of Components*

- Material choice
  - Radiation resistant
  - Low activation properties to reduce residual doses and minimize radioactive waste *(optimization with ActiWiz code)*

- Optimized handling
  - Easy access to components that need manual intervention *(e.g., valves, electrical connectors)* or complex manipulation *(e.g., cables)*
  - Provisions for fast installation/maintenance/repair, in particular, around beam loss areas *(e.g., plugin systems, quick-connect flanges, remote survey, remote bake-out)*
  - Monte Carlo calculations of residual dose rate, predictions of job doses and iterative design optimization

- Limitation of installed material
  - Install only components that are absolutely necessary, in particular in beam loss areas
  - Reduction of radioactive waste

Radiation Protection – *Optimization of Components*

Results obtained with ActiWiz (C.Theis, H.Vincke)

Steel 316L

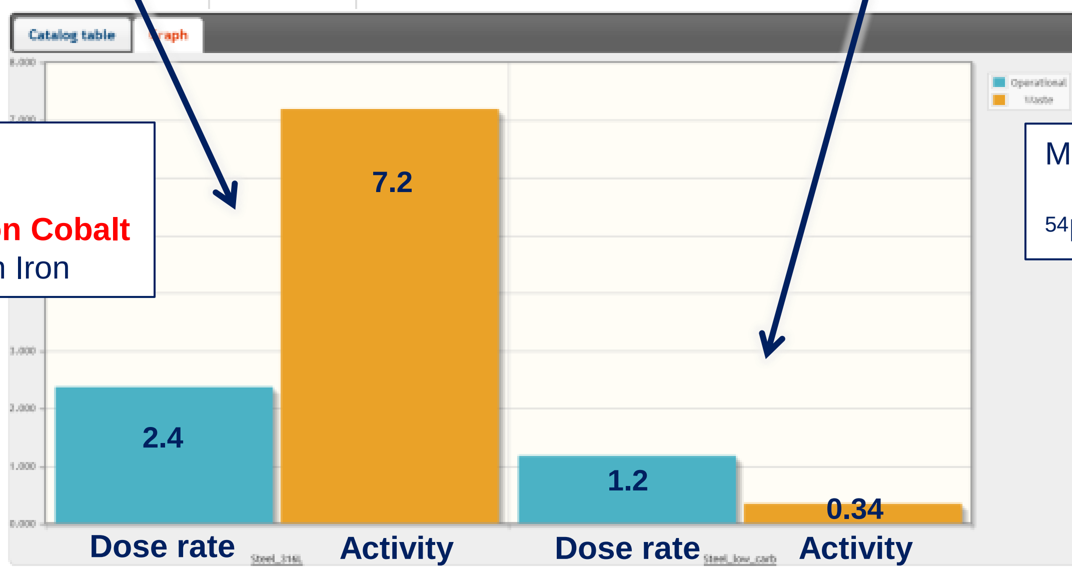
Element	Weight %
IRON	64.80
CHROMIUM	17.25
NICKEL	12.50
MOLYBDENUM	2.25
MANGANESE	2.00
SILICON	1.00
COBALT	1.00e-1
NITROGEN	5.00e-2
CARBON	3.00e-2
PHOSPHORUS	1.50e-2
SULFUR	

Cast iron

Element	Weight %
IRON	99.35
MANGANESE	0.45
CARBON	0.11
SILICON	5.00e-2
SULFUR	2.50e-2
PHOSPHORUS	2.00e-2

Main contributors:

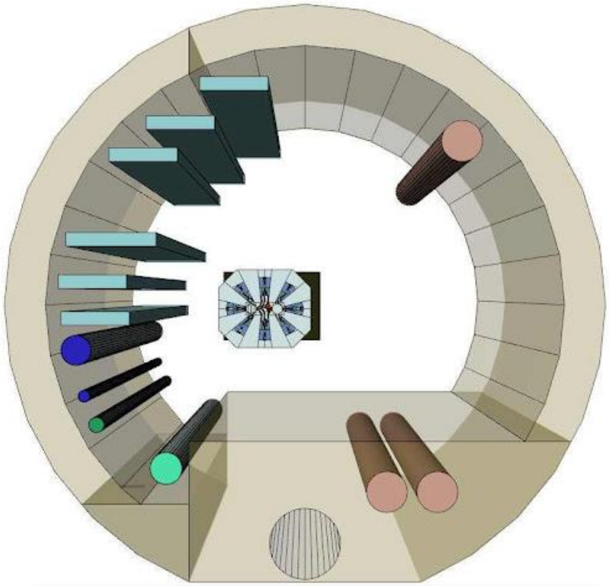
^{60}Co (61%) produced on Cobalt
^{54}Mn (37%) produced on Iron



Main contributor:

^{54}Mn produced on Iron

20 years irradiation
2 years cooling



- Beside other aspects also the radiological consequences of the implementation of a material, whether it's for an experiment, the machine or the infrastructure, have to be considered

- Level of activation depends on the type of the material

Safety benefit

- Lower dose rates and committed doses

Operational benefit

- Reduced downtime due to faster access
- Less restrictions for manipulation & access

End of life-cycle benefit

- Smaller amount and less critical radioactive waste
- Smaller financial burden

Radiological Environmental Aspects

- **Activation of air** :
  - Avoid /minimize releases
  - Location of release points outside densely populated areas
- **Activation of water** *(cooling and ventilation circuits, infiltration):*
  - The facility shall be designed so that water containing radioactive substances will be monitored, collected and treated.
- **Activation of rock and groundwater** surrounding the tunnels/caverns:
  - A hydrogeological study to evaluate the potential impact on groundwater
- **Aspects of stray radiation** to the surface:
  - Pits should be designed to prevent direct streaming of radiation to the surface (e.g. chicanes/plugs)
- **Identification of potential hazardous events** that may lead to an accidental release of radioactivity to the environment.

Conventional Environmental Protection

- **Energy**:
  - Power supply strategy shall give priority to renewable energy;
  - Accelerator/industrial facilities, administrative buildings and site services shall be designed to be energy efficient.
- **Water**:
  - Water supply strategy shall exclude the use of drinking water for non-sanitary purposes;
  - Foresee adequate water retention measures (e.g. buffer basins) on each site to regulate the flow discharged effluents (including rainwater from impermeable surfaces);
  - Design of cooling systems/cooling towers shall be done so as to limit legionella issues and impacts on effluent water quality.
- **Air**:
  - Define a strategy to limit the emissions of greenhouse gases within the accelerator and experimental facilities especially used for detector cooling and particle detection.
- **In addition,** specific measures related to mobility, noise, soil protection, waste, flora and fauna, landscaping, prevention of environmental accidents and non-ionizing radiation shall be identified in the frame of the **Environmental Impact Assessment**.

Fire safety – Prevention measures

- Strict limitation of the use of combustible materials since the concept phase;
- Fire rating of plastics and cables (self extinguishing, hard to ignite, low smoke, zero halogen, etc.);
- Limitation of ignition sources.

Cables from the ATLAS cavern in 2011

CTF3

Fire resistant cabinet

Fire safety – protection measures

- Limitation of the exposure of occupants (access mode);
- Fire detection system (smoke, heat, etc.) for early reaction of intervention teams;
- Automatic cut of the concerned electrical equipment;
- Automatic alarm system (smoke detection, manual, remote, etc.) for early evacuation (by sectors);
- Transportation means to evacuate rapidly (long egress distances) and to quickly bring intervention teams on place;
- Ad-hoc and standard fire fighting and rescue equipment stored underground.

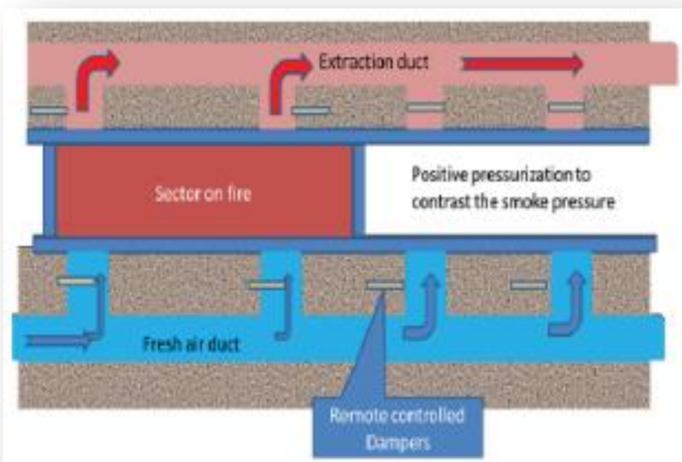
Single point optical detector

Sampling pipe smoke detector

From the presentation CLIC CES Webex 12 Nov. 2008, CERN-SC

Fire safety – protection measures

- “Smart” **evacuation management**
  (e.g. safest evacuation paths are updated according to fire scenario via dynamic panels)
- **Automatic extinguishing sy**stems for early fire attack;
  (Extinguishing agent may be activated => collection volumes)
- **Smoke management sy**stem (e.g. via dedicated ducts or integrated in the air management system) for smoke and fire confinement, to facilitate egress, search and rescue mission and manual extinguishing activities; Smoke may be activated => collection volumes;
- **Personal localization system** to facilitate search and rescue activities
  (see XFEL; Gotthard tunnel worksite)
- **Fire compartmentalization** *(walls or water curtains)* to facilitate evacuation and intervention and to limit the extent of damage.



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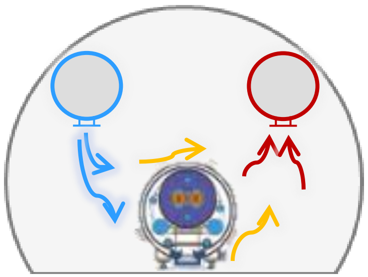
Air management

- Smoke extraction could be integrated in the ventilation system profiting from the same control system and infrastructure

  → Transversal ventilation could prevent smoke propagation.



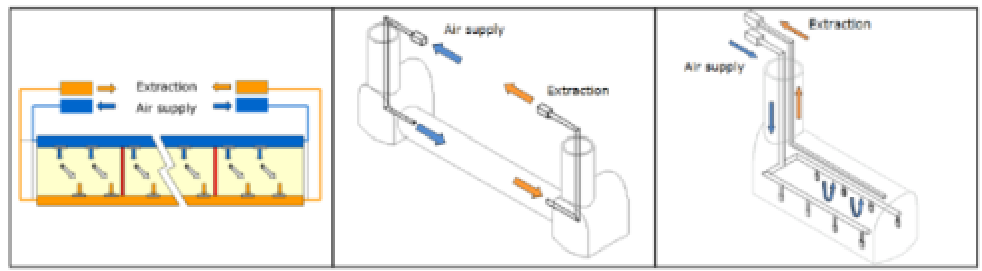
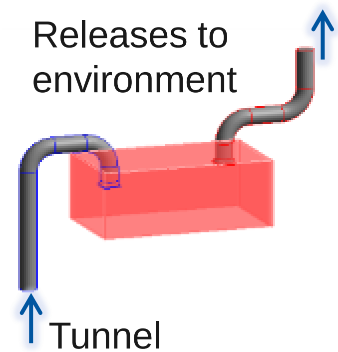


Fig. 6.22: Ventilation schemes: (left) semi-traversal, (centre) longitudinal and (right) ventilation for caverns

CLIC Conceptual Design Report – Geneva 2012

- Reduce releases of activated air by:

  - Reducing the heat load of equipment → reduced air flow rate;
  - Decay volumes in the air extraction system: an option?



- Foresee routing of the exhaust of safety devices of the cryogenic systems to a non occupied area of the tunnel

Some thoughts for the layout

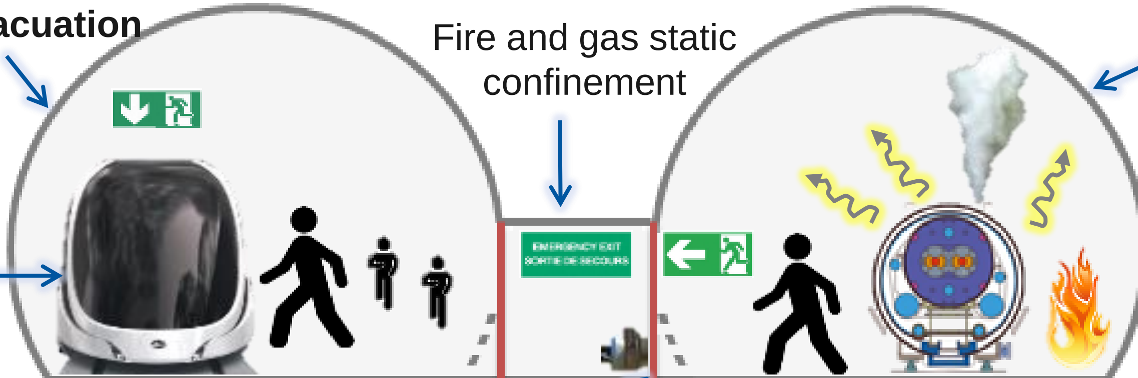
- **Isolate the main hazards form the occupants!**

“Safe zone” - Tunnel for access / evacuation

Fire and gas static confinement

“Hazard zone” Beam tunnel

Means of transportation



SRM only needed at the entrance of the beam tunnel

OR

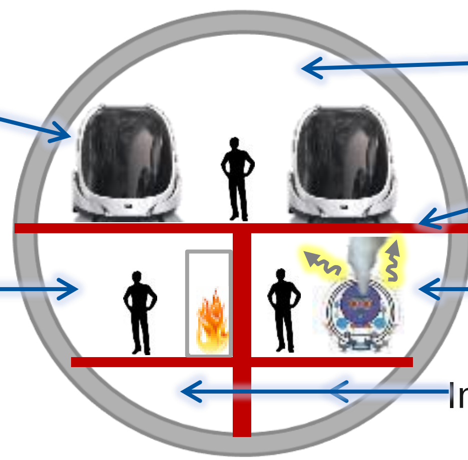
“Safe zone”
Tunnel for access / evacuation

Means of transportation

Fire and gas static confinement

“Intermediate Hazard zone”
Service tunnel

“Hazard zone”
Beam tunnel



Infrastructure gallery – cables, pipes, ducts…

Some final remarks

Integration of all **safety aspects** as early as possible will allow ***experiments, machine(s) & infrastructures*** of the FCC project to implement ***best practice*** and ***new concepts***

- to ensure the best possible prevention and protection,
- to limit the impact on the environment.

This will save time and resources during all project phases.

Particular attention shall be paid to what concerns:

- material characteristics in view of radiation protection and fire prevention
- remote transport, handling and manipulation
- tunnel layout: *concept of hazard-intermediate-safe zone*
- air management systems in view of radiological aspects, *fire protection and oxygen deficiency hazard*

A pro-active & corporate integrated Safety approach *for the benefit of FCC*

Thank you

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