Safety topics requiring further investigation

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- Scope of the CDR Study
- Safety Objectives met
- Future Studies
  - Fire Safety
  - Cryogenic Safety
  - Radiation Protection
- Conclusions

Scope of the CDR Safety Study

- Identification of hazards, based on project breakdown structure, and “Standard Best Practice” to cope with them.
- Three safety domains require special treatment:
  - **Fire** in underground facilities
  - **Cryogenics** in underground facilities
  - **Radiation Protection**
- Safety performance based study for Fire and Cryogenics
  - Safety Objectives
  - Facility lay-out + Safety infrastructure + Realistic accident scenarios
  - Evaluation of safety objectives (Life, Environement, Property, Continuity of operation).
- Standard prescriptive measures for Radiation Protection

Safety Objectives

- Life Safety Objective
  - Occupants are able to escape from the facility during accident scenarios. Rescue teams can safely intervene.
- Environmental Protection Objective
  - During accident, limited amounts of pollutants are emitted to air and water
- Property Protection Objective
  - Essential services continue operating, the accident will not cause further incidents and the loss of property is limited
- Operational Continuity Objective
  - The downtime after the accident is acceptably long

CDR Safety Study: Fire

- Tunnel design
  - fire compartments every 440 m and
  - conceptual design and sizing of smoke extraction
- Scenarios
  - Fire dynamics simulations for 3 accident scenarios
- Meet the Life safety objective:
  - no victims among occupants and fire fighters

Fire Safety: Compartments

- Fire Compartments
  - Difficulty: Accelerator and its services must pass
  - How ? Return of experience from SPS
  - When ? In parallel with accelerator installation of immediately afterwards ?
  - Safety concepts based on autonomous, rail-based vehicle: needs to pass

Fire Safety: Property / Environment

- Property Protection:
  - Detailed evaluation of heat radiation/ convection
  - Assessment of structural tunnel safety (heat < 10 MW)
  - Smoke contamination
- Environmental Protection:
  - Release of smoke and polluted water
  - Release of slightly radioactive particles with smoke: inclusion in fire dynamics simulations on the way (FIRIA – project)

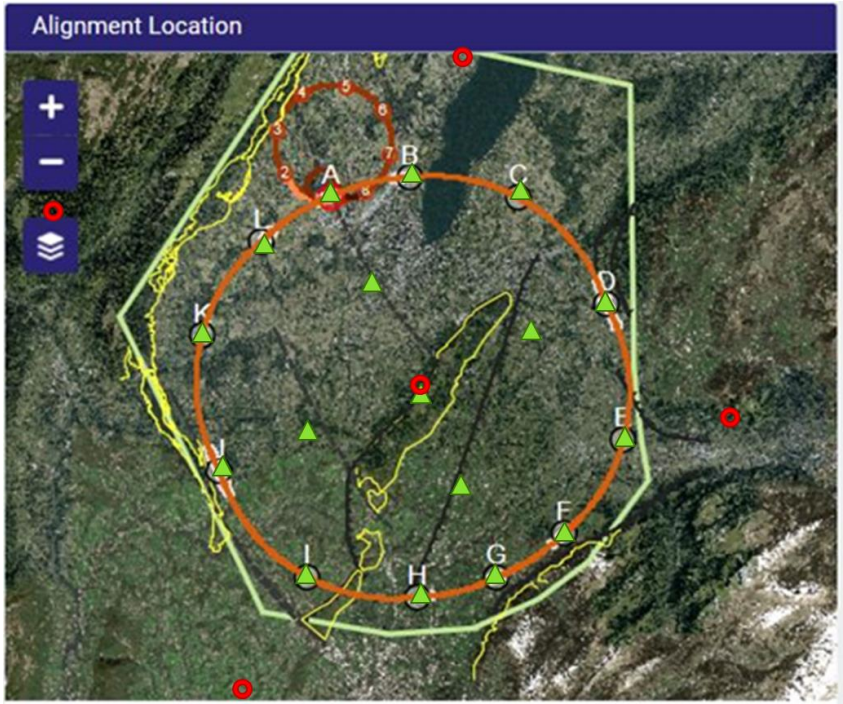
Fire Safety: Fire Brigade

- Fire Brigade Operations

Tribune deGenève

Geneve est sacrée capitale Suisse du bouchon routier

- Intervention time from Meyrin Site prohibitive
- Decentralised CERN fire brigade at each access point ?
- Collaboration with local fire brigades (rural area, voluntary services) ?
- **FCC Concept for fire and rescue required**



Fire Safety: To-Do

e^+ / e^-	h h
Fire load in Klystron galleries (oil-insulated RF modulators)	

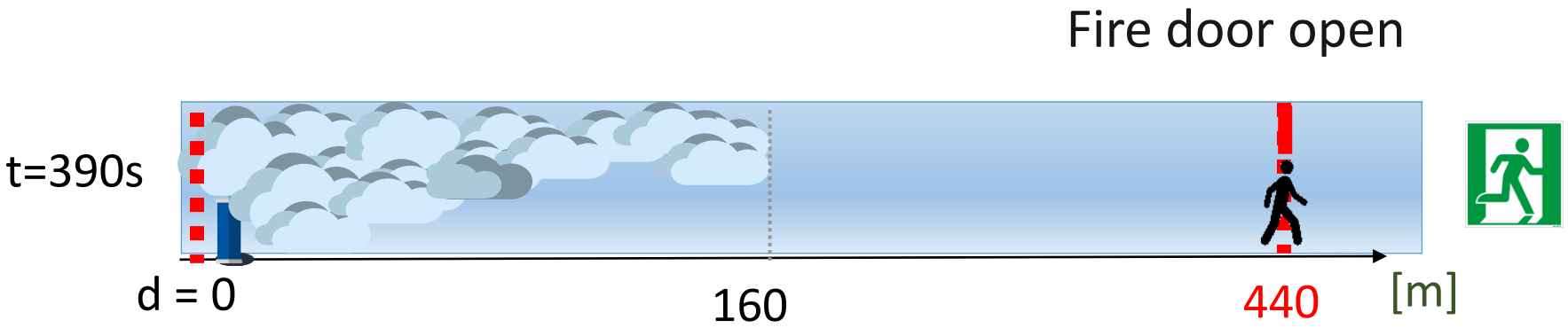
Both Projects
Construction of the compartment walls, transport during shutdowns
Logistics of Fire & Rescue Service: central fire station not suitable
Extinguishing means in underground areas
Release of radioactive particles with smoke and extinguishing water (→ RP)

CDR Safety Study: Cryogenics

- Tunnel design
  - (fire) compartments every 440 m and
  - (Smoke) extraction, used for cold helium gas
- Scenarios
  - 6 accident scenarios with Helium release rates between 100 g/s and 32 kg/s
  - Simple analysis of helium gas volumes and height of breathable layer
- Meet the Life safety objective
  - Release rate < 300 g/s: no victims
  - When higher spill rates possible, restrict access

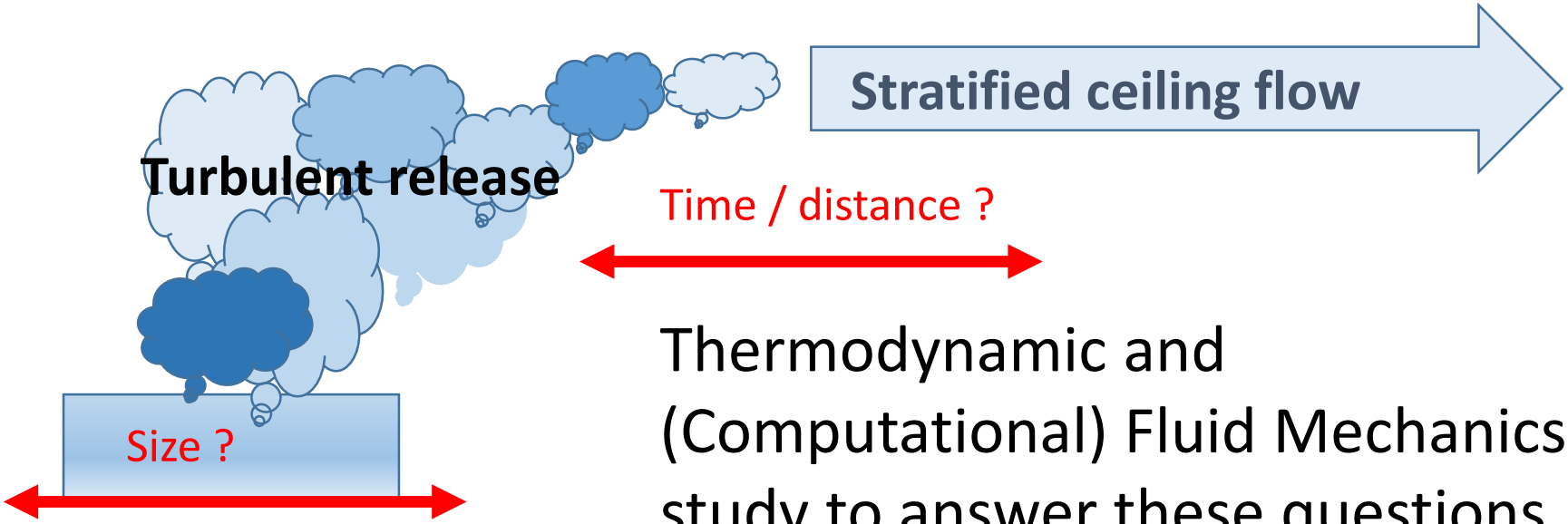
Cryogenic Safety: Compartments

- (Fire) Compartments:
  - Behaviour at high Helium release rates (capacity verified until mass-flow of 1 kg/s)
  - Pressure build-up
- (Smoke) extraction:
  - Behaviour at low temperature
  - Brittleness, condensation



Cryogenic Safety: Fluid Dynamics

- Present knowledge of helium release flow:
  - Mostly qualitative description
  - Few experiments (LHC He-spill test, 2014)
  - CFD description of few scenarios



Thermodynamic and (Computational) Fluid Mechanics study to answer these questions

Cryogenic Safety: To-Do

e^+ / e^-	h h
Rapid Helium release from RF cavities	Behaviour of tunnel compartment walls (pressure)
	Behaviour of smoke extraction with cold helium
Both Projects	
Detailed study of the thermodynamics and (turbulent fluid-flow of released Helium)	
Safety devices for elongated cryostats (cold powering, cryogenic supply line)	

CDR Safety Study: Radiation Protection

- Standard Radiation Protection design criteria

	CERN sites		Off-site
	Radiation workers	Other personnel	Members of the public
Limit	6 - 20 mSv/y	1 mSv/y	0.3 mSv/y
⇕	Optimisation required (ALARA)		⇕
Optimisation threshold	100 µSv/y	10 µSv/y	10 µSv/y

Prompt radiation in areas accessible during operation
Singular losses (incident event)
< 6 mSv: designated area
< 1 mSv: non-designated area
Continuous losses (nominal operation)
< 10 µSv/h: controlled radiation area
< 3 µSv/h: supervised radiation area
< 0.5 µSv/h: non-designated area

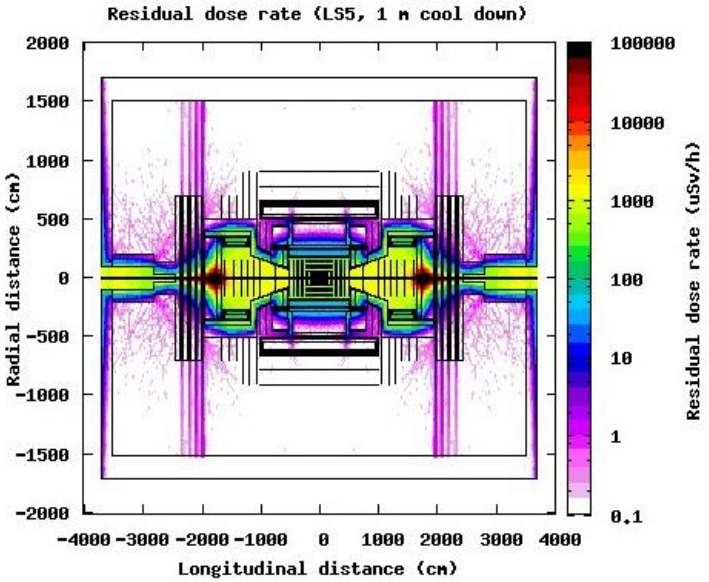
- Determination of radiation levels and induced radioactivity in arcs, collimation, triplet and experimental areas (impact for access and maintenance) for the hh-collider
- Design of ventilation systems with recycling scheme to minimise environmental impact
- Preliminary estimates for activation by synchrotron radiation for the ee-collider

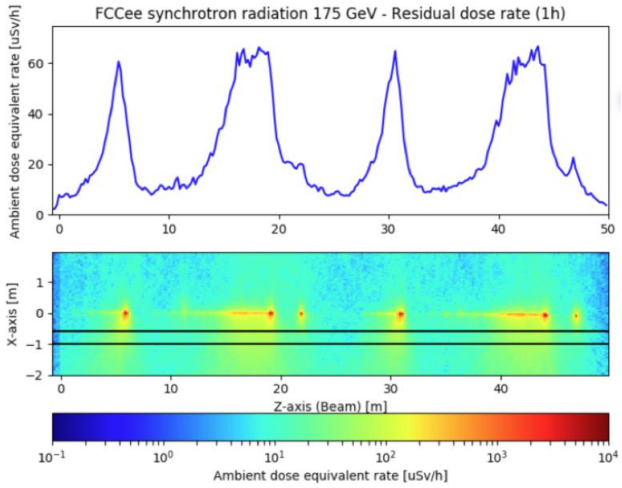
Radiation Protection: Effluents

- Accelerator operation activates tunnel air and cooling water
  - Released via shafts to the environment
- Impact assessment:
  - Monte-Carlo radiation transport calculation (FLUKA)
  - Model of ventilation/cooling circuits
  - Comparison with target figures in host states
- Special concern:
  - Effluents during fire, release of slightly activated particles and water (FIRIA-project)

Radiation Protection: Activation

- More detailed activation studies needed for
  - Planned loss points (collimators, dumps)
  - Experiments
- Activation by synchrotron radiation and beam in the ee-collider



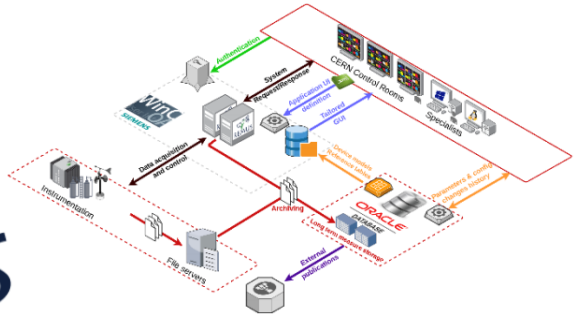


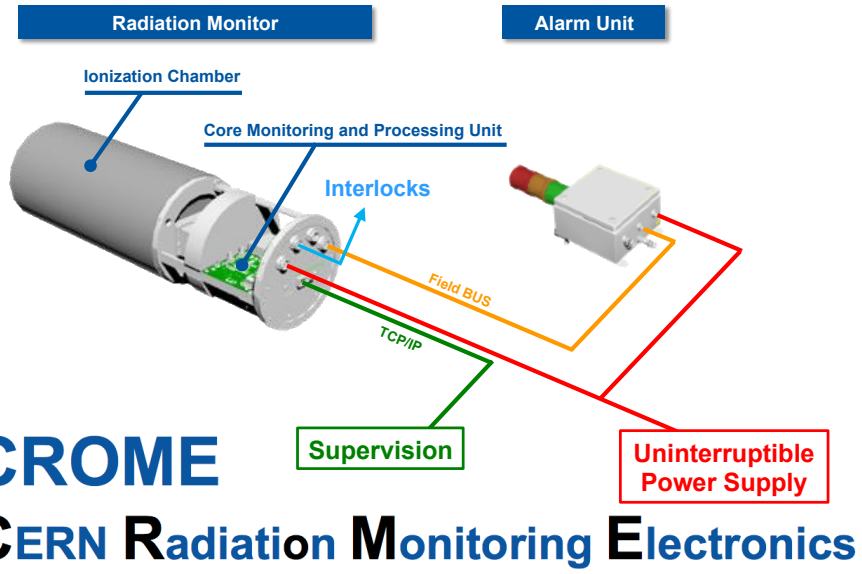
Radiation Protection: Monitoring

A radiation monitoring program for workers, public and environment must be designed

REMUS

RADIATION AND ENVIRONMENT MONITORING UNIFIED SUPERVISION





CROME

CERN Radiation Monitoring Electronics

Radiation Protection: To-Do

e^+ / e^-	h h
Refined activation study for synchrotron radiation	Detailed activation studies and intervention scenarios for experiments & mitigation of high radiation levels
Activation by e^+/e^- at loss points (experiments, collimators, dumps)	
Validation of shielding study derived from hh (proof of conservatism)	
Both Projects	
Management of effluents (air, water) and their environmental impact	
Activation studies for experiments, based on more detailed detector designs	
Design of radiation monitoring program for occupational and environmental exposure	
Management of radioactive material and waste (storage, flow)	

Summary 1

- The CDR Safety Study demonstrated that planned facilities can meet the Life Safety Objectives
- Additional studies are necessary for a TDR:
  - Fire Safety:
    - Implementation of fire compartmentalisation
    - Impact of fire scenarios on property and environment (slightly radioactive particles)
  - Cryogenic Safety
    - More accurate description of Helium releases
    - Interaction of cold gas with smoke extraction, pressure on compartment walls

Summary 2

- Additional studies are necessary for a TDR:
  - Radiation protection
    - Radioactivity in experiments and beam loss points
    - Management of effluents (air and water)
    - Radiation monitoring programme
- Precise study programme will be determined once CERN's strategy is defined
  - Specific topics in e^+/e^- collider:
    - RP: synchrotron radiation
    - Cryo: strong, short term He-release from RF
    - Fire: fire load from Klystrons

Thank you for your attention