Sprinkler systems to protect the world's largest particle physics installations

At CERN, the European Organization for Nuclear Research, physicists and engineers are probing the fundamental structure of the universe. They use the world's largest and most complex scientific instruments to study the basic constituents of matter – the fundamental particles.

In 2020, CERN completed the consolidation of fire safety systems in its second biggest accelerator, the Super Proton Synchrotron (SPS). As a part of this project, a water-based sprinkler system was installed following principles of standard industrial design but customized and tailor-made for the SPS and its irradiated areas. The system needed to take into account limitations related to the presence of fragile accelerator equipment, radioactive environment, and strict integration constraints, as well as to comply with European norms, in particular EN12845. Factors such as radiation resistance of the components and installation and maintenance in time-limited-stay areas were part of the design challenges. After a successful modernization of the SPS systems, CERN starts in 2022 a major refurbishment of its fire safety systems in the North Area experimental complex (NA).

This session presents motivations which have driven CERN to launch the fire safety renovation projects. The presentation aims to lay out options considered by CERN while selecting the most adapted solutions based on the unusual environment constraints. Lessons learned from the SPS project design and installation will be shared and considered in light of the preparations underway for the NA project.

ANNA SUWALSKA - European Organization for Nuclear Research (CERN)

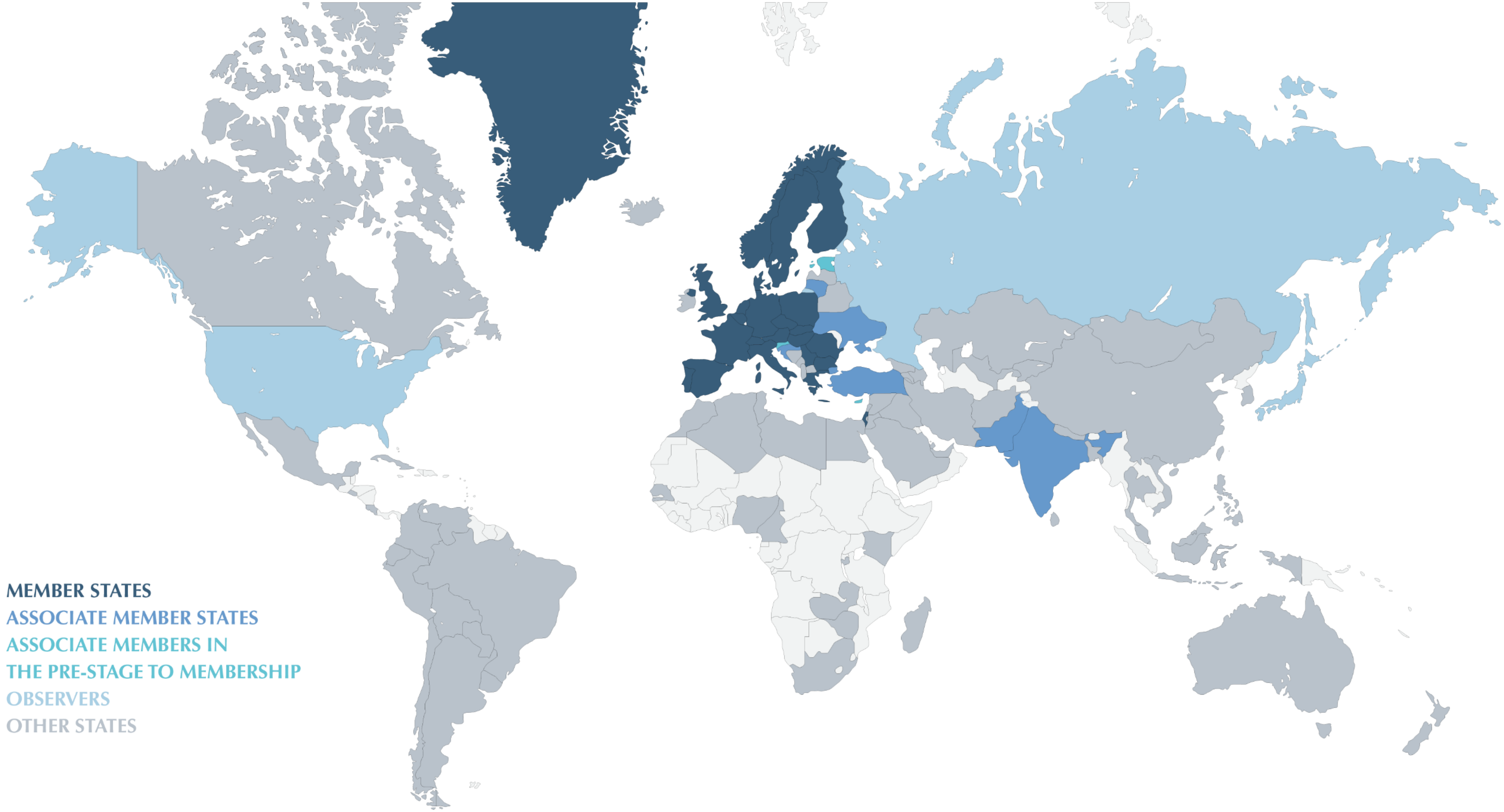
Agenda

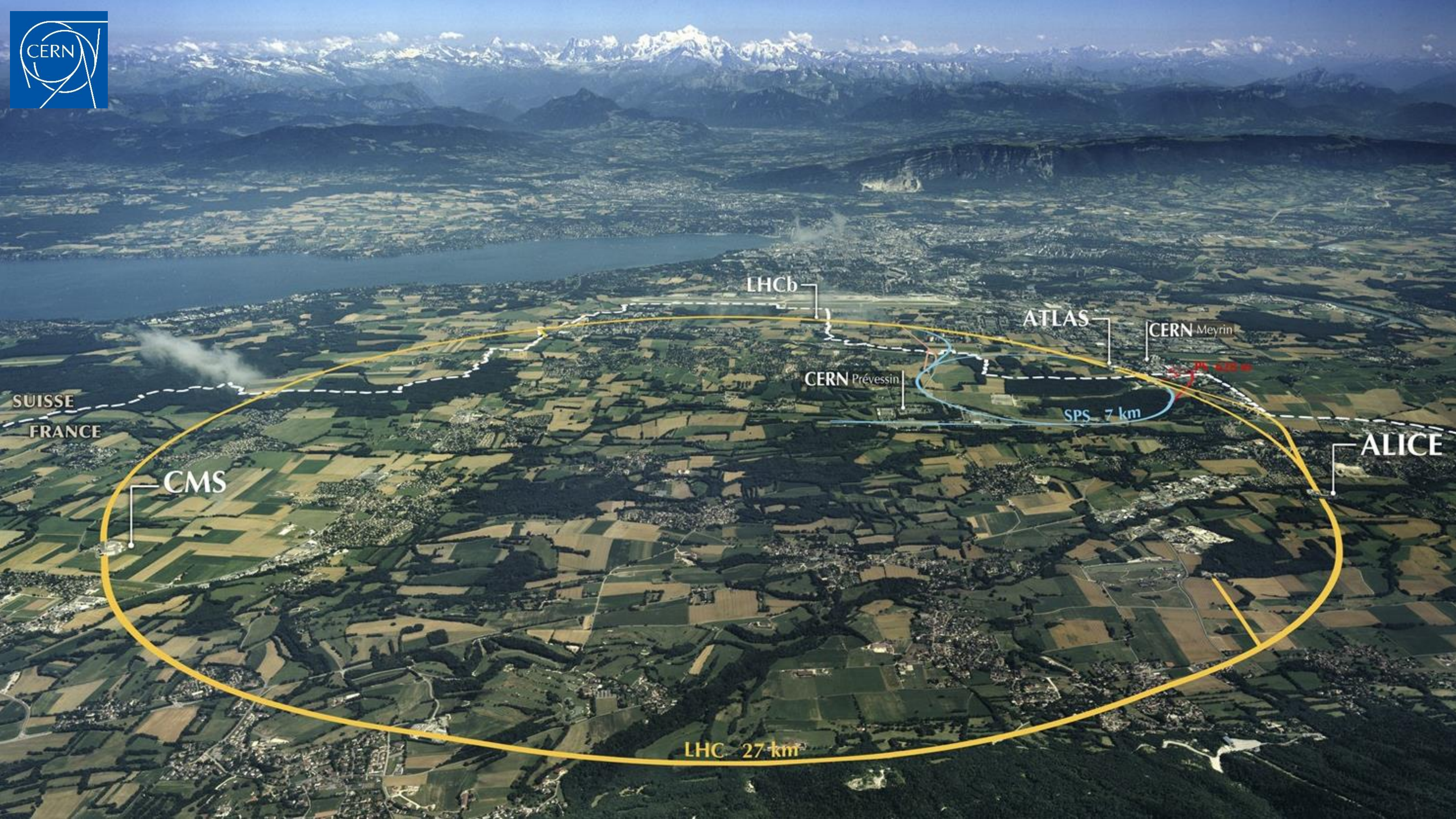
- Introduction to CERN & the SPS
- SPS Fire Sprinkler Protection
- Next fire safety projects at CERN
- Conclusion

Agenda

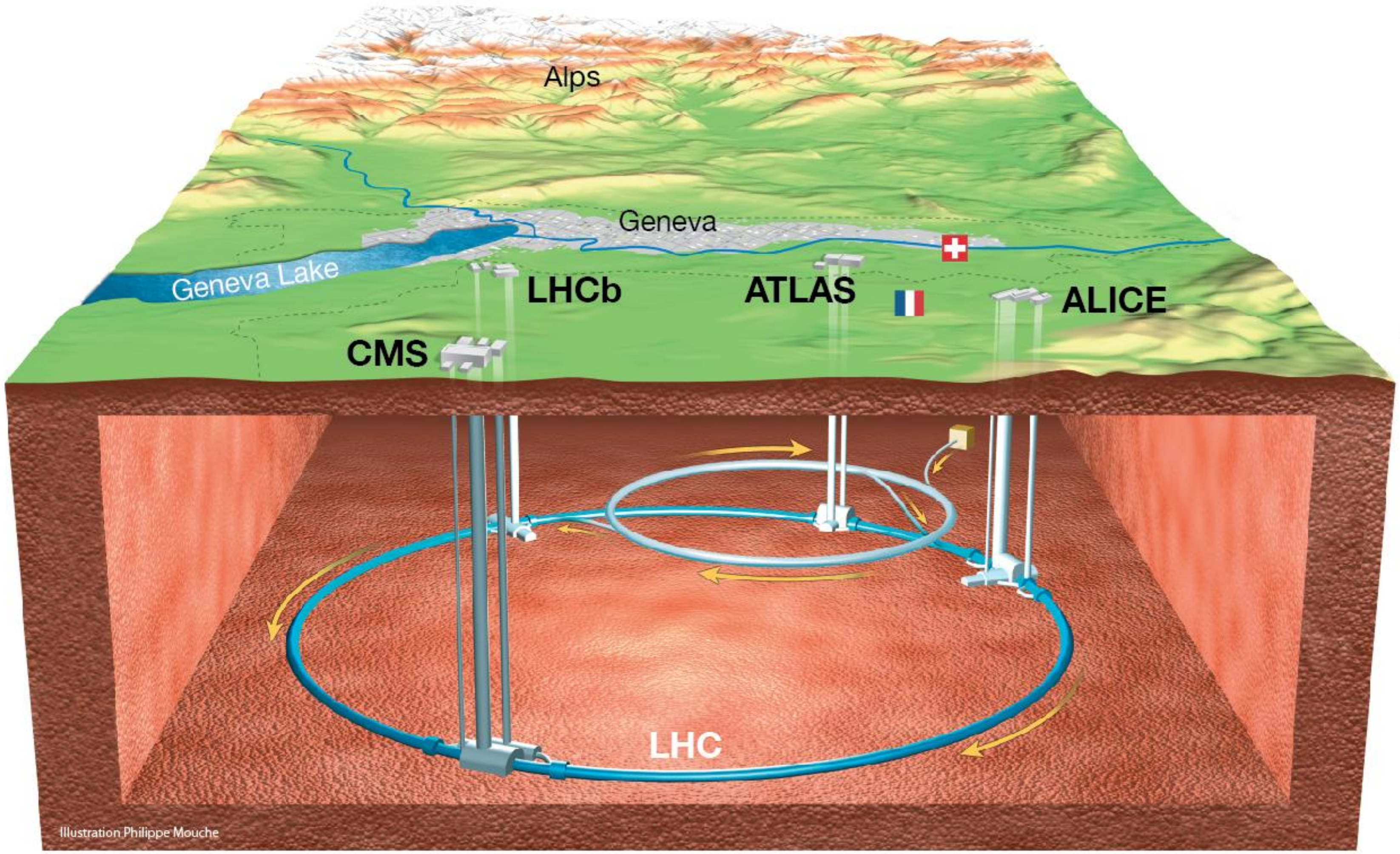
- Introduction to CERN & the SPS
- SPS Fire Sprinkler Protection
- Next fire safety projects at CERN
- Conclusion

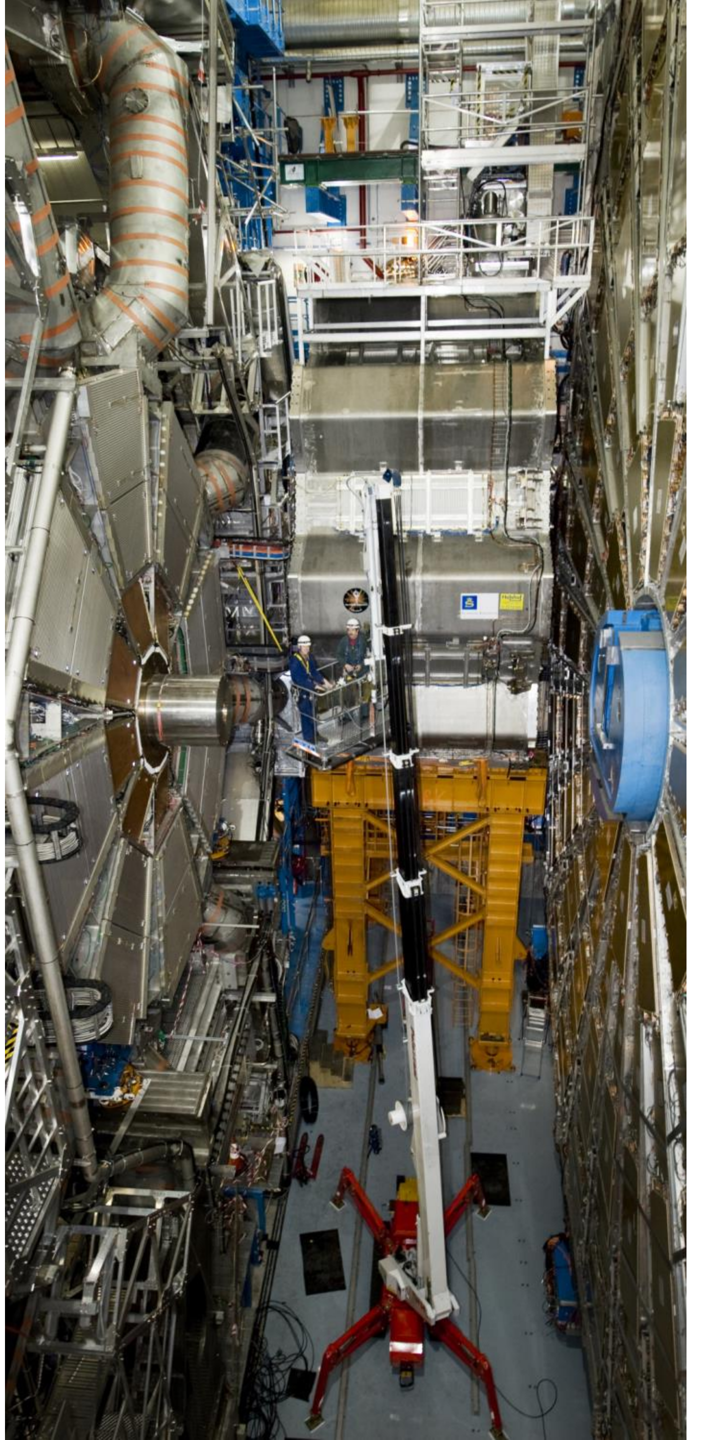
CERN – International Collaboration




LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km

Accelerators layout

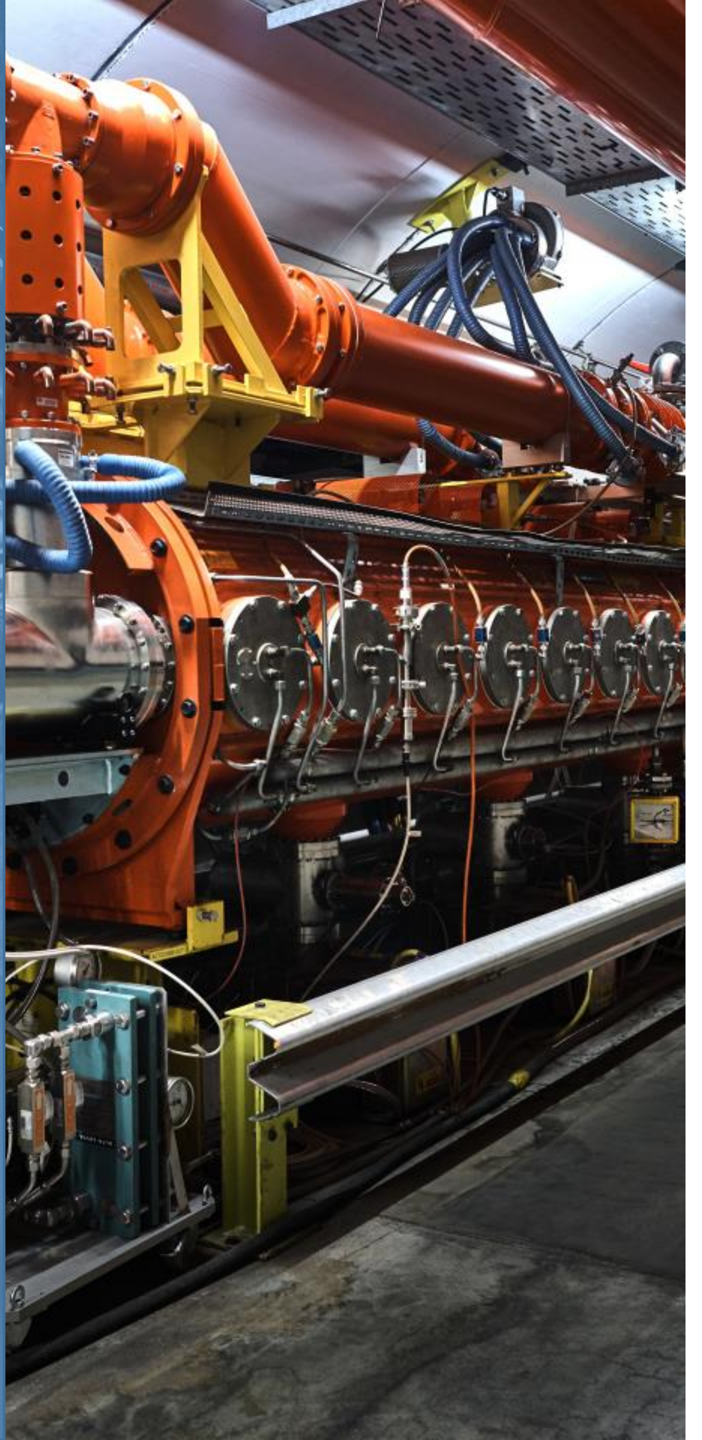




Not only physics…

Super Proton Synchrotron

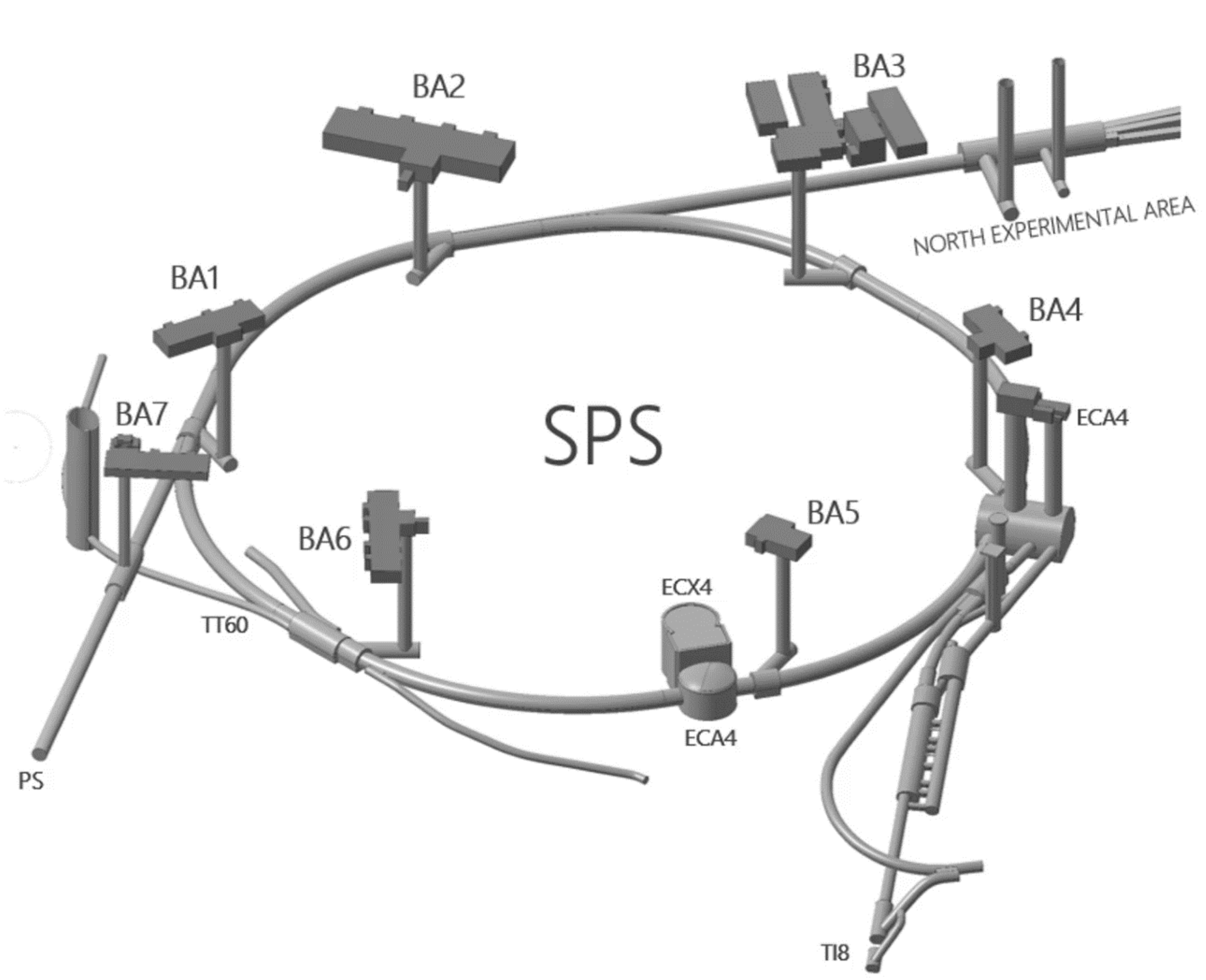
- Second largest machine in CERN’s accelerators complex.
- Built in early’70 and operational since 1976.
- Takes particles (protons or Pb-ions) from the Proton Synchrotron and accelerates them to provide beams for the LHC, the North Area experimental complex and AWAKE facility.
- 1317 conventional (room-temperature) electromagnets, including 744 dipoles to bend the beams around the ring.



Agenda

- Introduction to CERN & the SPS
- SPS Fire Sprinkler Protection
- Next fire safety projects
- Conclusion

SPS



Go to the SPS 3D [video]

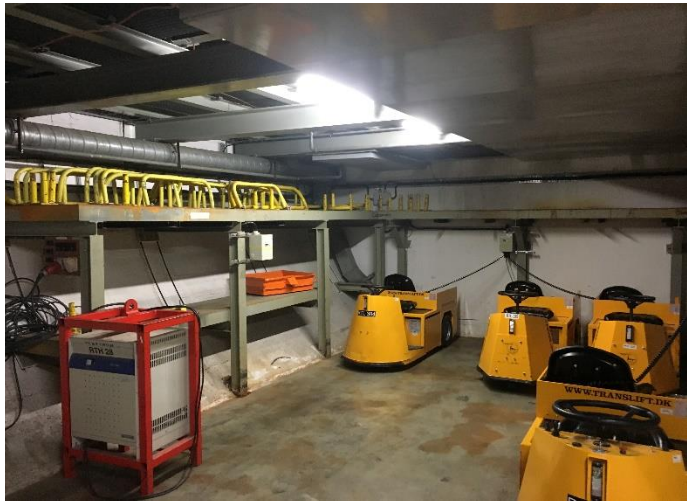
Risk Assessment

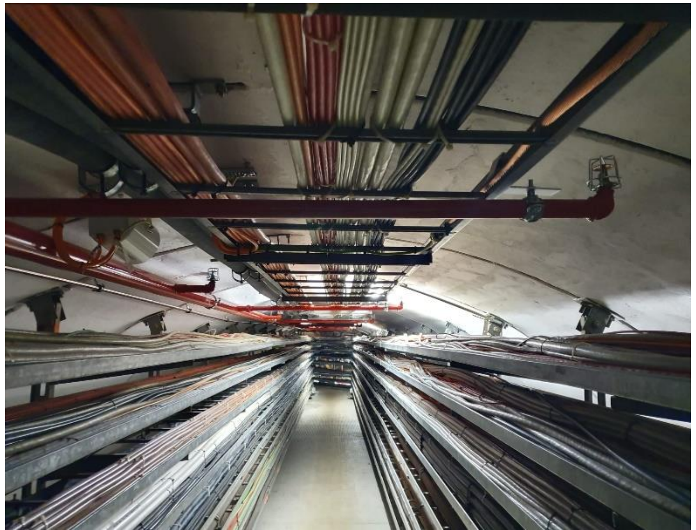
Combustible material in SPS

- Cable insulation dating to 70's
- Magnet coil insulation
- Electric trolleys and their batteries
- Material introduced during intervention or construction works
- Waste

Potential sources of ignition

- Faulty electrical equipment including faulty connections
- Hot works such us welding, grinding, brazing (only in access mode)
- Bake-out equipment
- Electric trolleys, batteries and associated charging equipment
- Intentional malicious action

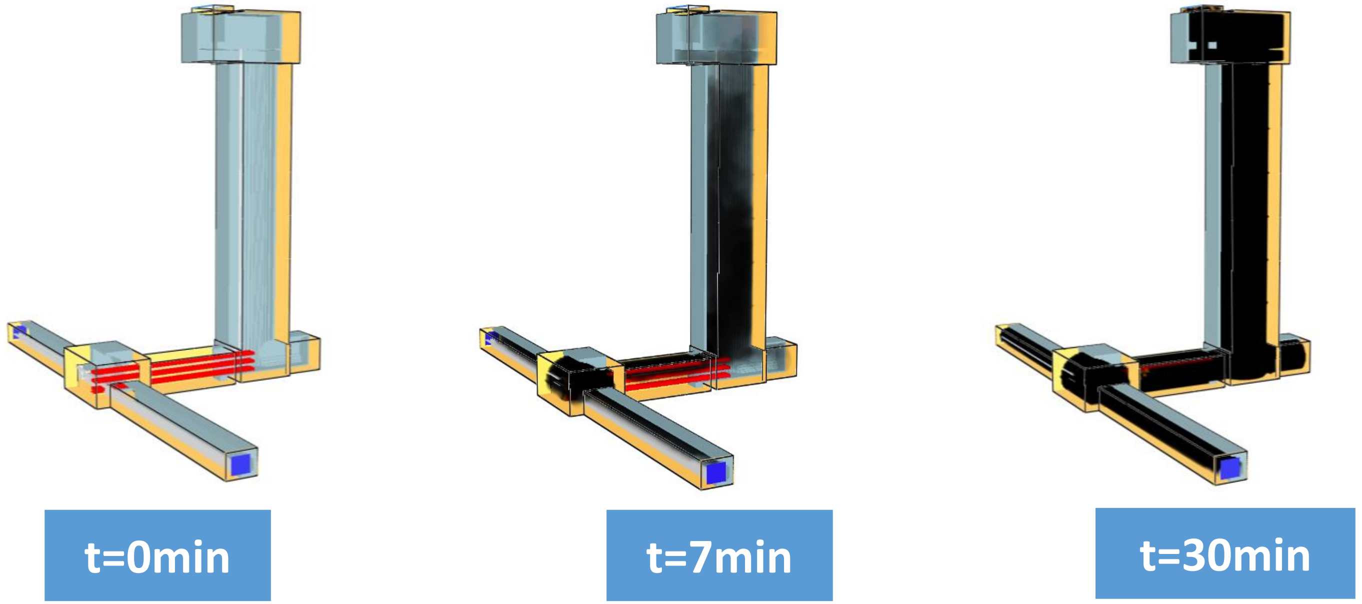




Safety Constraints

Safety constraints highlighted by the study

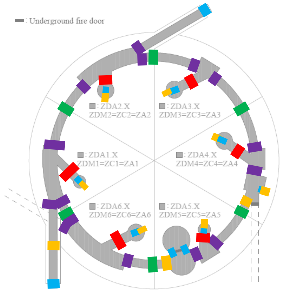
- High fuel load
- Activated smoke
- Lack of compartmentalization
- Extremely long engagement distance for firefighters
- Long evacuation routes exposed to smoke (up to 1.5km between the access points)



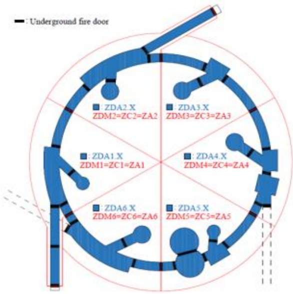
SPS Fire Safety strategy

Work Packages

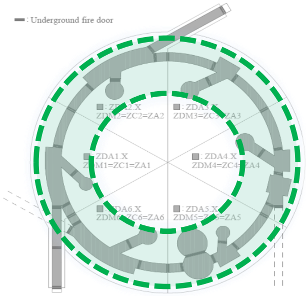
- WP1 Fire Compartmentalization
- WP2 Integrated Fire Safety Action System
- WP3 Dry Risers and dedicated fire service vehicles
- **WP4 Fire Sprinkler Protection System**



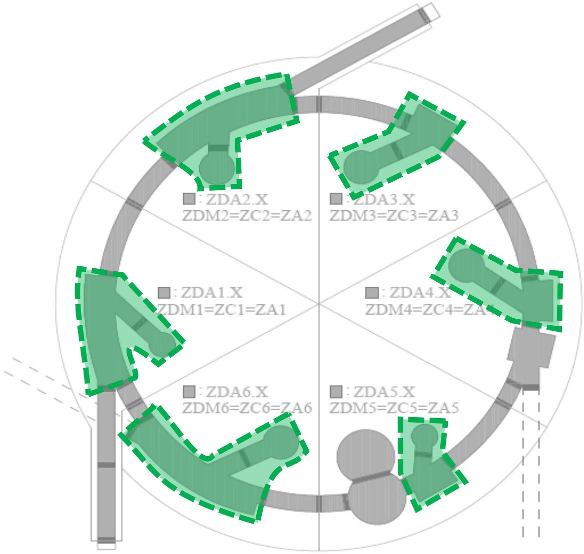
WP1



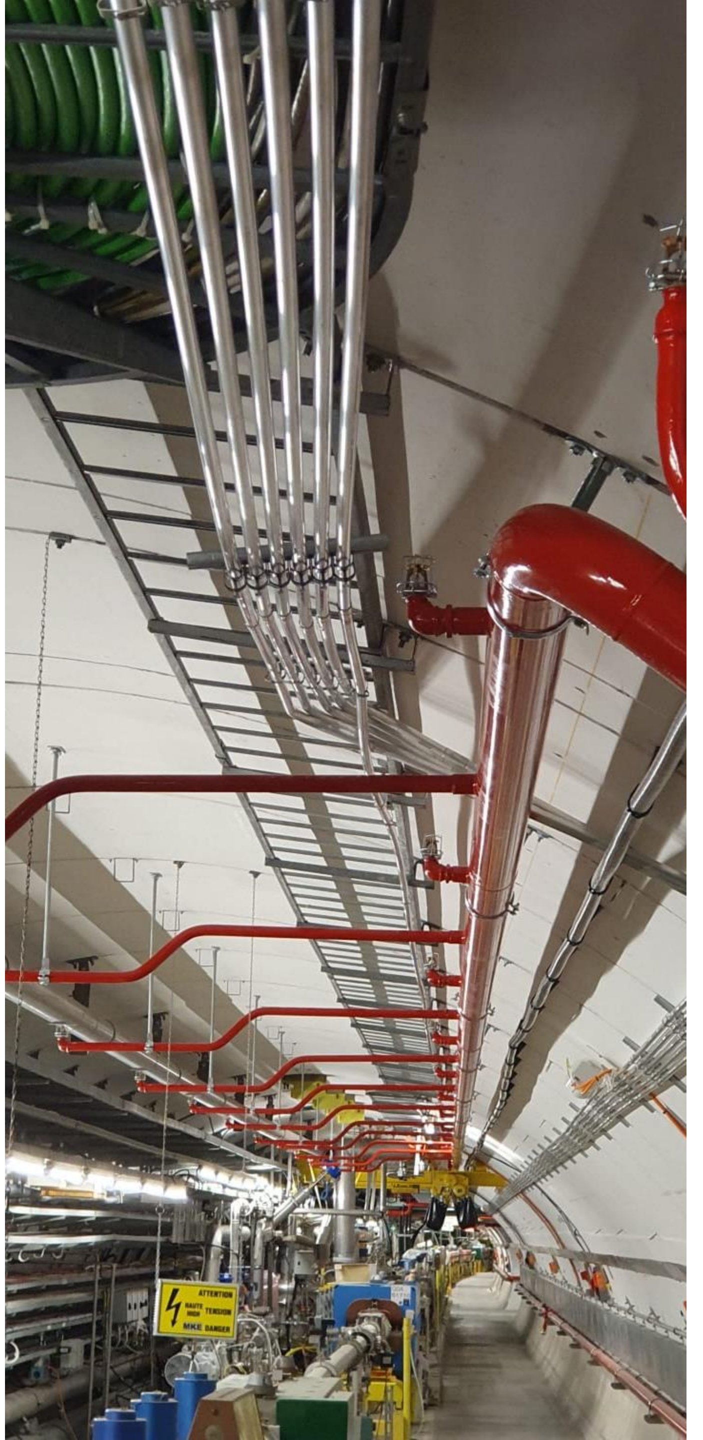
WP2



WP3



WP4



System options*

Wet pipe systems

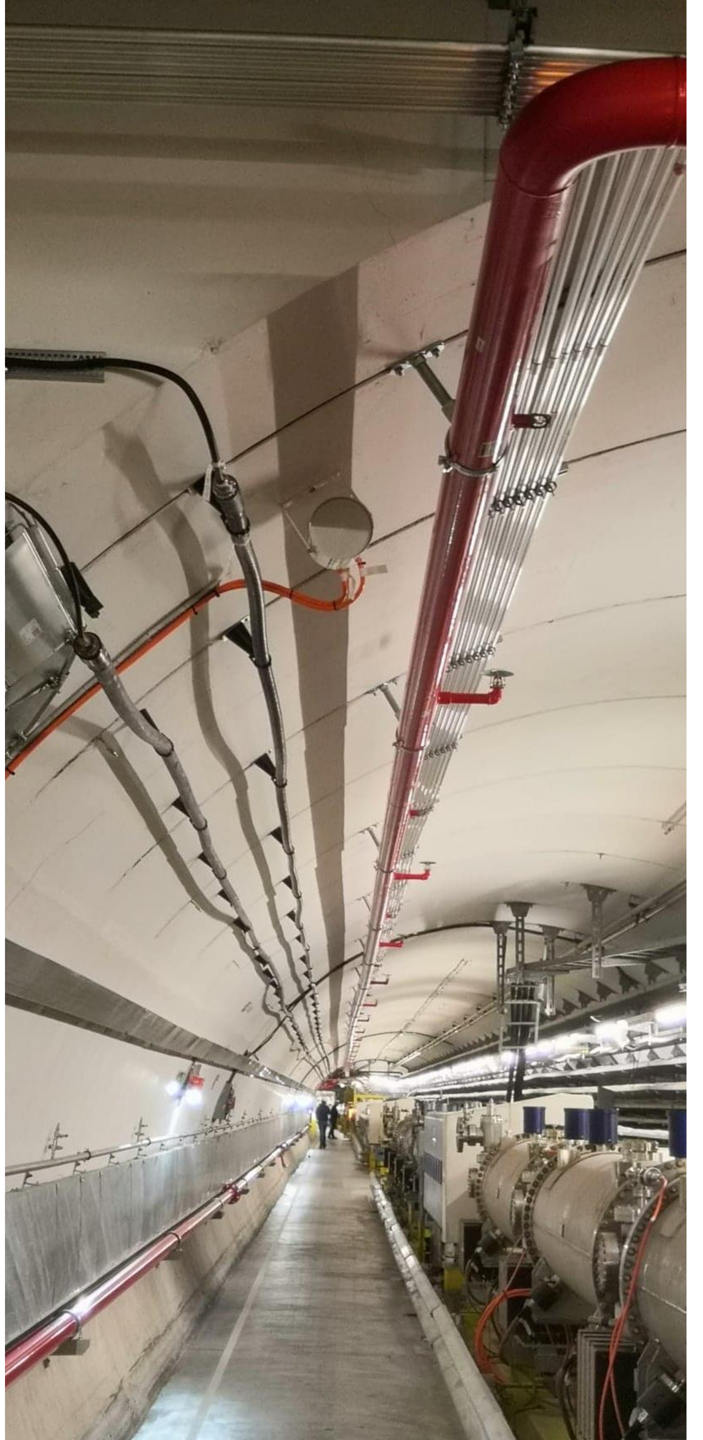
Dry pipe systems

Double interlock pre-action systems

Deluge systems

* Specific challenges

- Electromagnetic and particle **radiation exposure** to system components and the water inside piping.
- The **limited capacity** of the water drainage system and sumps.



System options

Wet pipe systems

YES

- The simplest, most reliable and least expensive of the four system types discussed
- Immediate discharge of water, e.g. the least number of sprinklers expected to activate of the three system types using automatic sprinklers

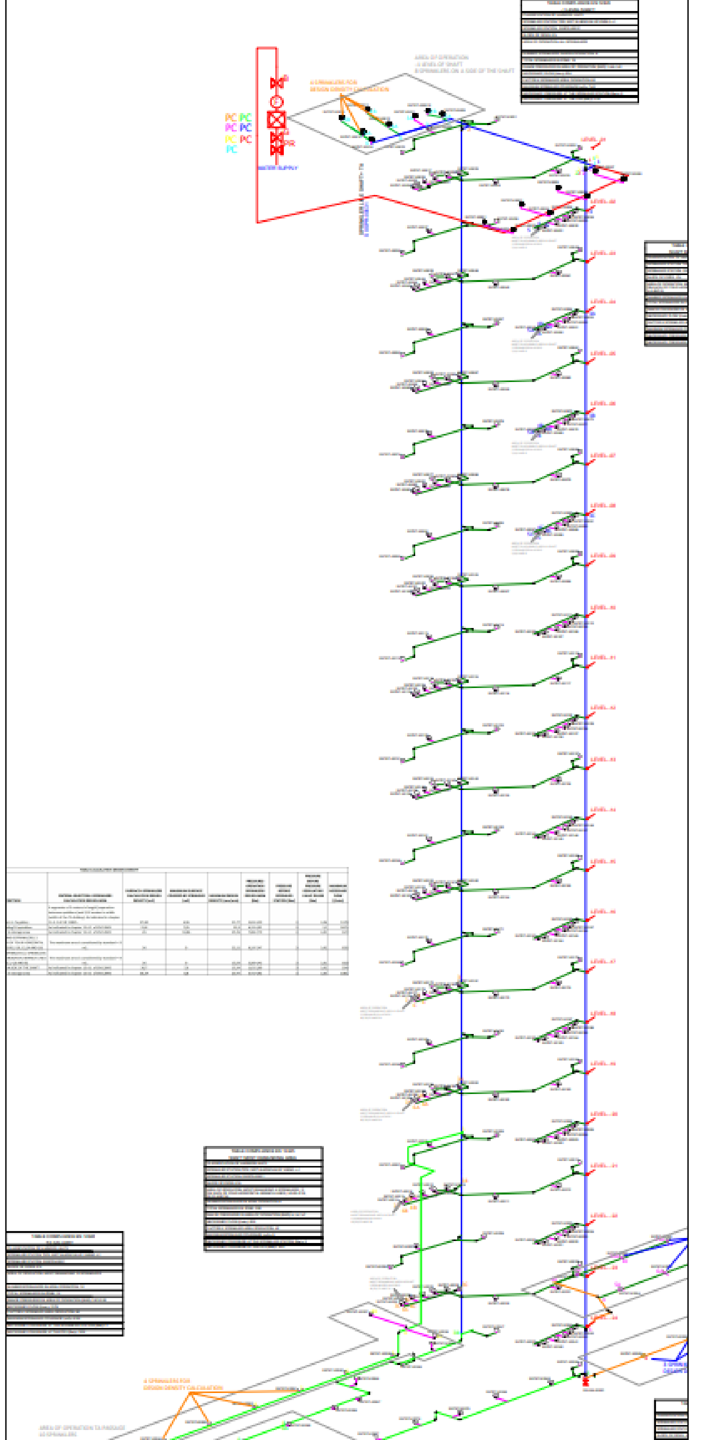
BUT..

- Risk for water damage upon accidental discharge
- Water in piping exposed to radiation

Dry pipe systems

- No water inside piping, e.g. no water exposed to radiation

- More complex, less reliable and more costly as compared to a wet-pipe system
- Risk for water damage upon accidental discharge
- Delayed discharge of water, e.g. a larger number of sprinklers expected to activate compared to a wet-pipe system
- More prone to severe internal pipe corrosion than a wet-pipe system



System options

Double interlock pre-action systems

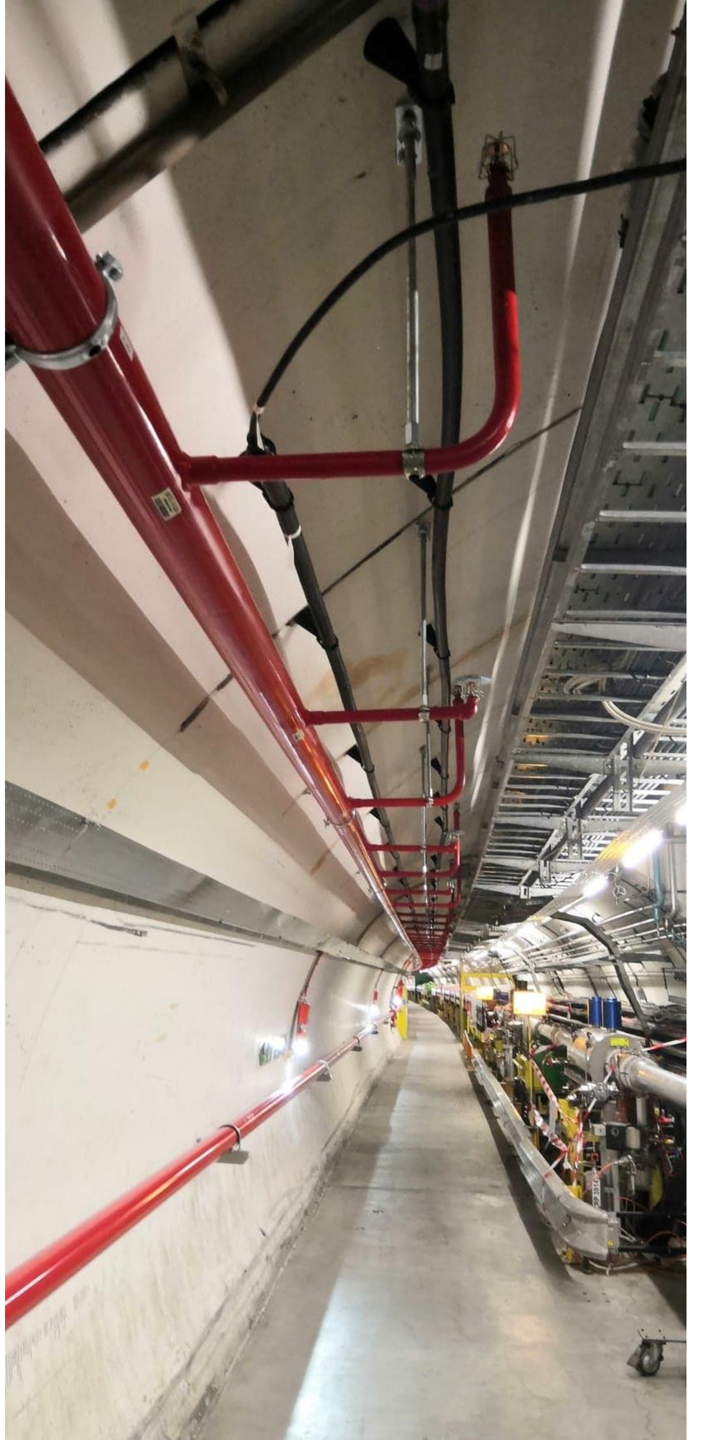
- No water inside piping, e.g. no water exposed to radiation
- Low probability for accidental discharge of water

- More complex, less reliable and more costly as compared to a dry-pipe system
- Need an additional fire detection system(s) for detecting the fire before releasing water into the system piping
- Delayed discharge of water, more prone to severe internal pipe corrosion as compared to a wet-pipe system

Deluge systems

- No water inside piping, e.g. no water exposed to radiation
- Careful positioning of directional discharge nozzles may improve the fire suppression performance as compared to the over-head sprinklers typically associated with the other three system types
- Early activation possible (e.g. smaller fire) with a careful selection and application of the fire detection system
- Manual (remote) discharge of the deluge zones may be possible

- Increased system complexity with deluge valves for each deluge zone
- Need for a fire detection system to initiate discharge
- Fire detection zoning need to correlate with the deluge zones
- A false fire detection will result in the discharge of one or several deluge zones
- Delayed discharge due to the water travel time from the deluge valve to the nozzles
- More prone to severe corrosion than a wet-pipe system, although probably less disposed to internal pipe corrosion than a dry-pipe system as humid air inside system piping may ventilate out

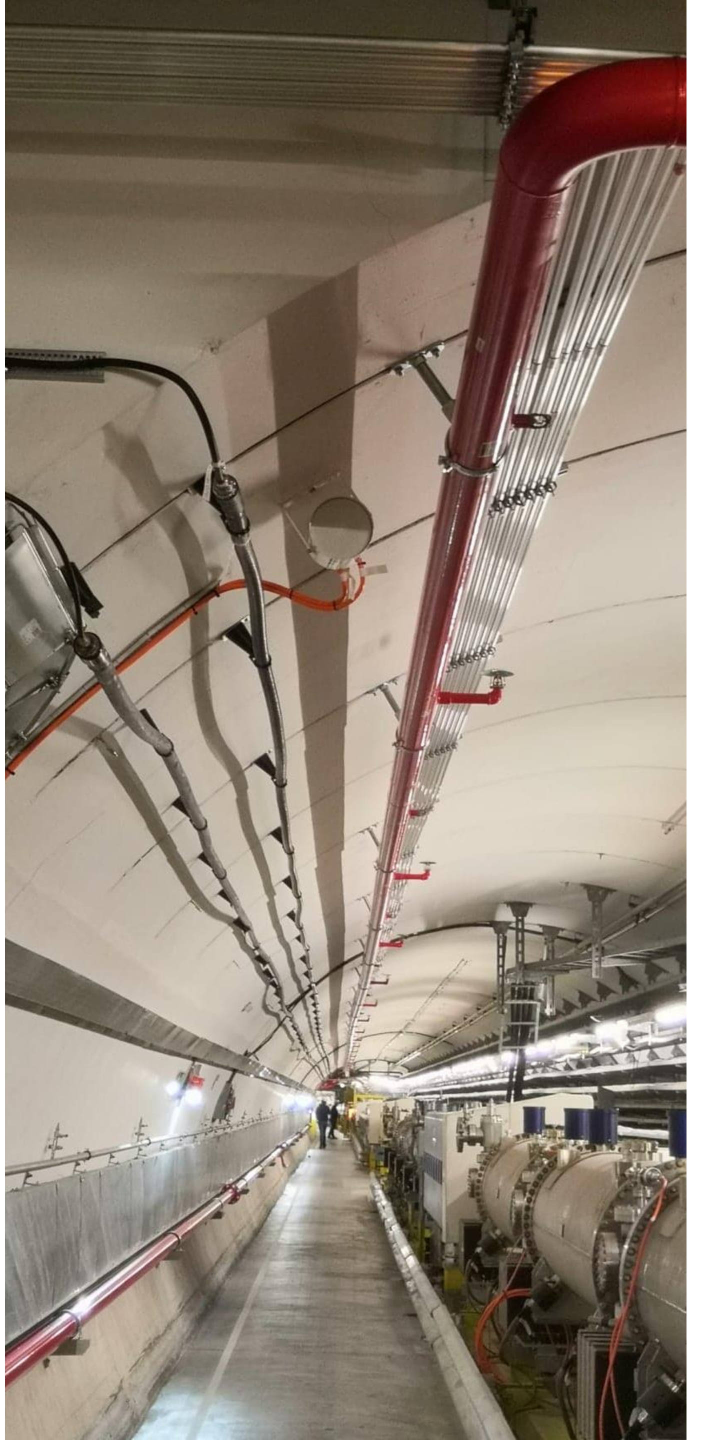


System options*

- Wet pipe systems
- Dry pipe systems
- Double interlock pre-action systems
- Deluge systems

* Specific challenges

- Electromagnetic and particle **radiation exposure** to system components and the water inside piping.
- The **limited capacity** of the water drainage system and sumps.



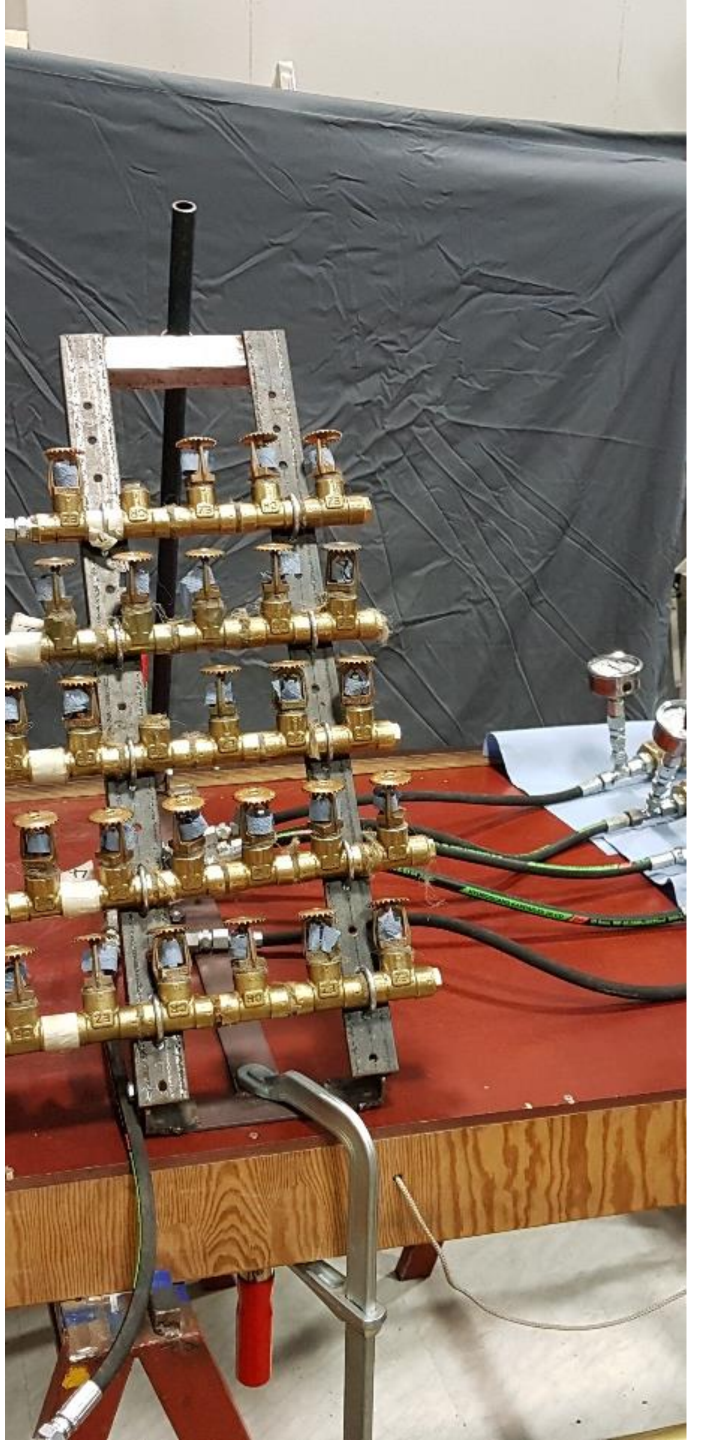
Equipment test

Co-60 gamma irradiation

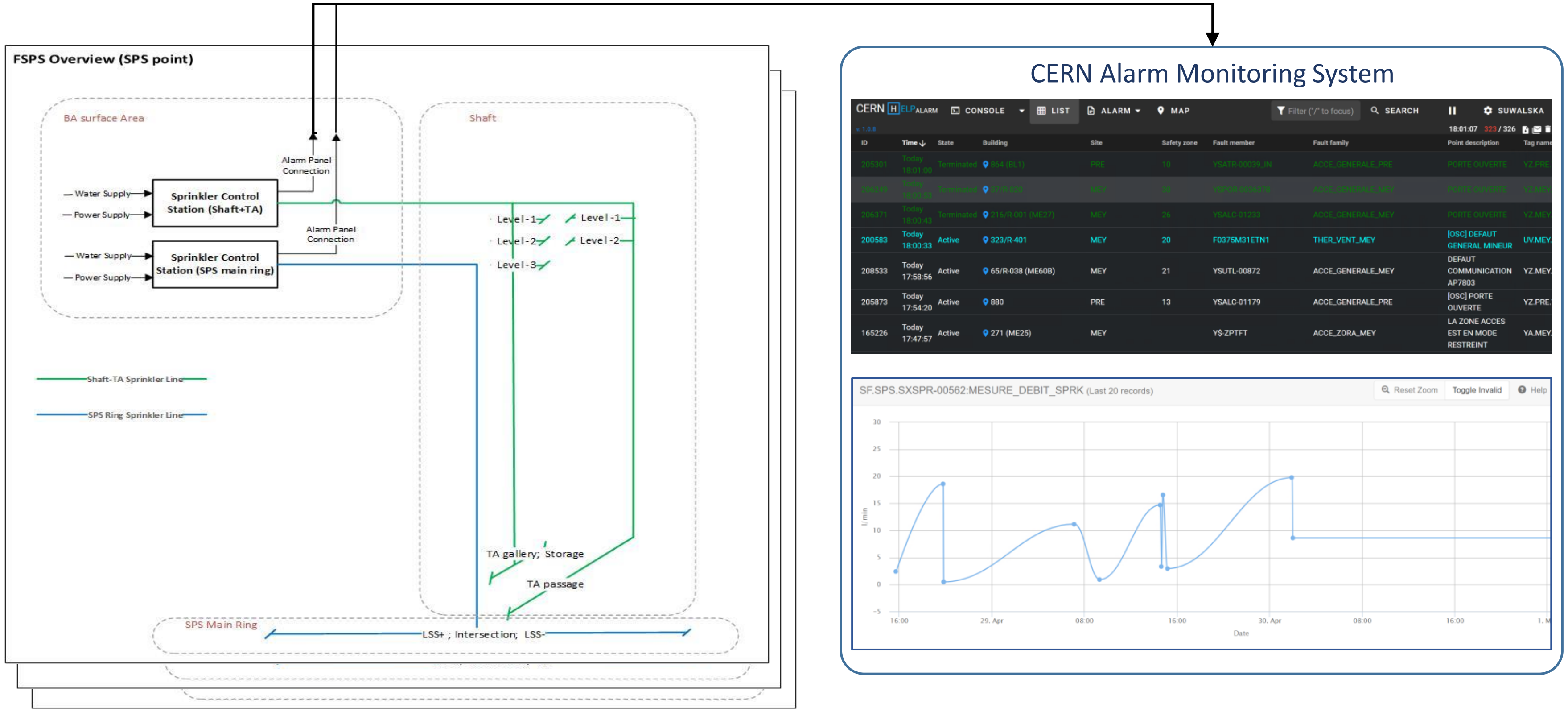
Dose Level	Brand A	Brand B	Brand C	Total Sprinklers
0 kGy (unexposed lot)	5	5	5	15 samples
5.8 kGy	5	5	5	15 samples
17.4 kGy	5	5	5	15 samples
52.2 kGy	5	5	5	15 samples
500 kGy	5	5	5 x	15 samples
1 MGy	5	5	5 x	15 samples
3 MGy	5	5	5 x	15 samples
Total	35	35	35	105 samples

ISO 6182-01:2014 tests

- Leak resistance and hydrostatic strength §7.10
- Thirty-day leakage resistance §6.21
- Dynamic heating §6.14
- Operating temperature §7.4



System overview



Design Constraints

Material and equipment constraints

- Radiation resistant material, PTFE[1] not authorized
- Black steel pipe; welded or threaded couplings
- Radiation-tested equipment only

Technical constraints

- Design and installation according to EN12845
- Quick response, high pressure sprinkler heads
- Reversed configuration
- Water reuse during maintenance (radiation constraints)

Integration constraints

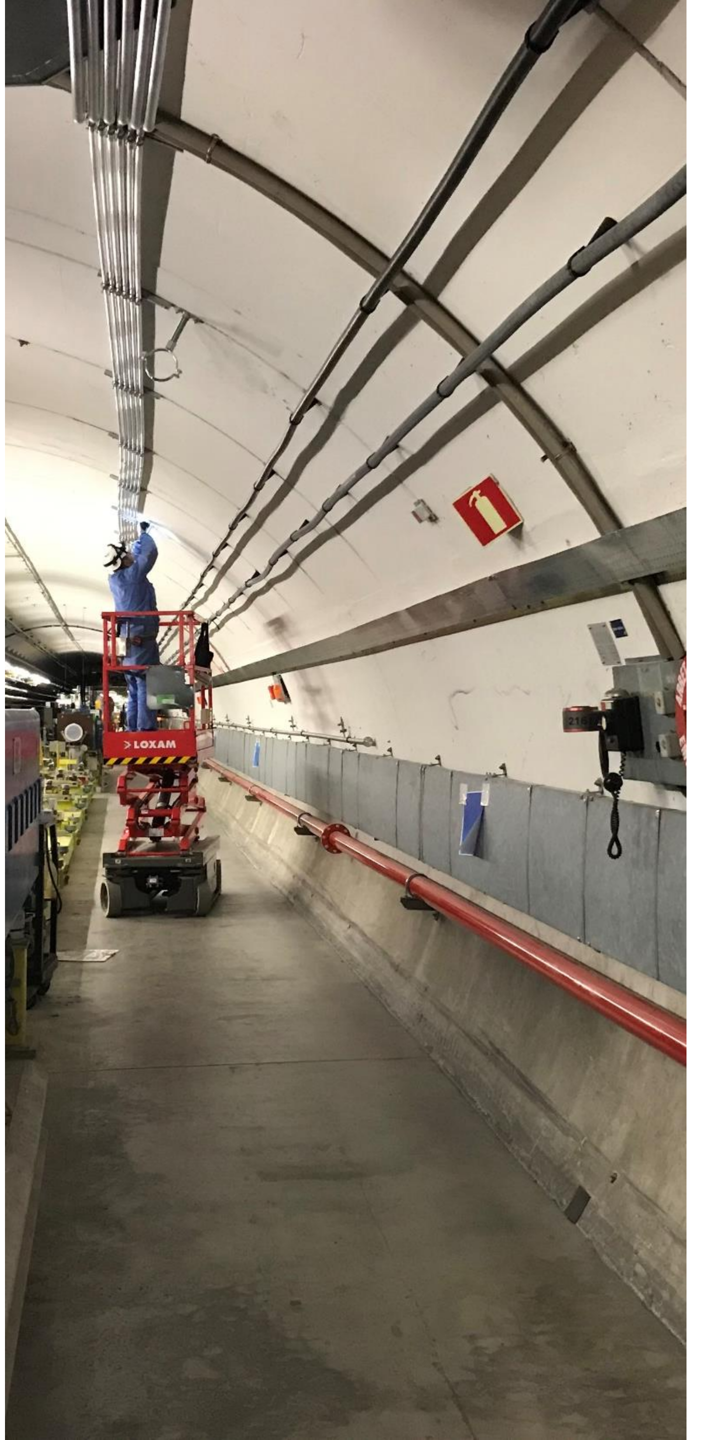
- Minimal 400mm horizontal distance from the machine and its equipment
- Minimal 200mm horizontal distance from cable trays
- Very limited space and lack of routing options
- Non obstructed sprinkler discharge path to be preserved

[1] PTFE: Polytetrafluoroethylene(Teflon)

Installation Constraints

Installation challenges

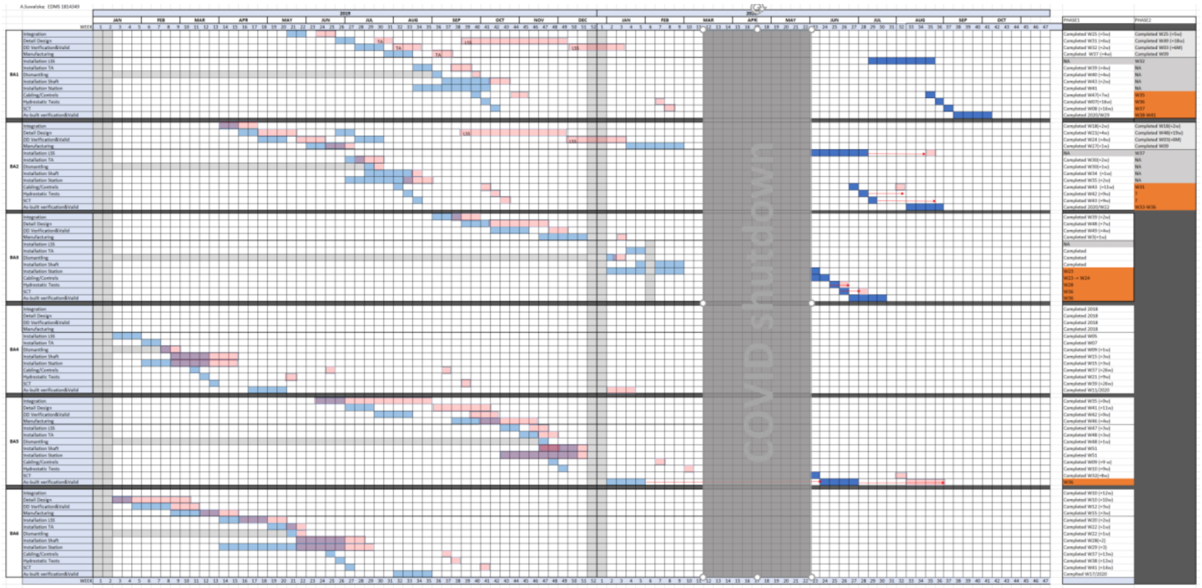
- Safety of workers and co-habitants
- Reduced accessibility and work at height
- Optimization methods for the “time-limited stay area”
  - Dedicated tools
  - Customized assembling methods and transport means
  - Enlarged teams (workers replacement)
  - Workshop in a safe place
- Machine protection for welding, equipment handling, high-pressure tests

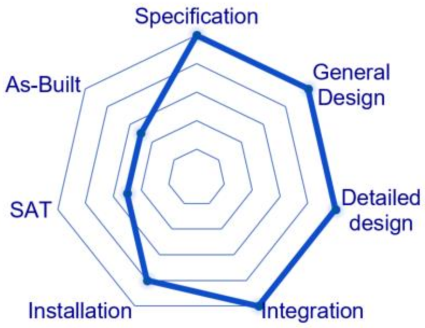


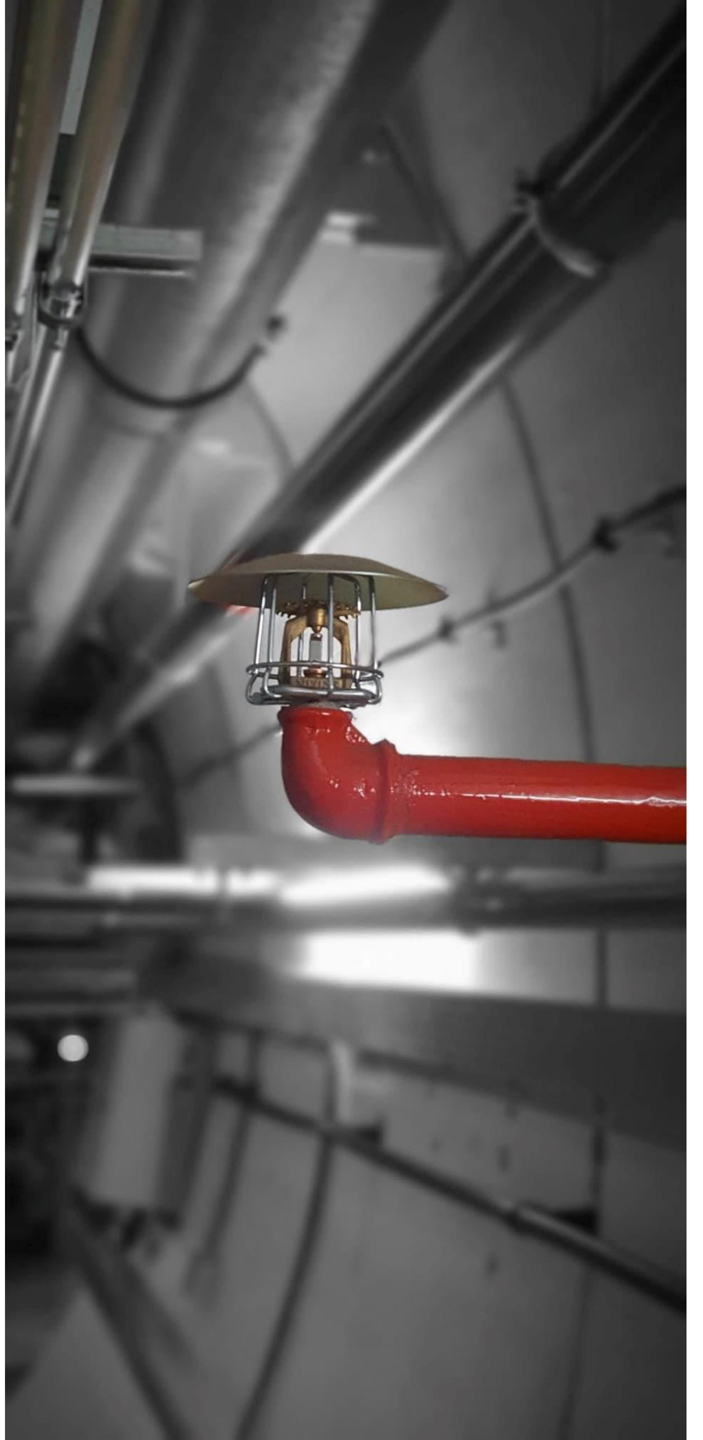
PM - planning and coordination

Project planning and coordination

- Consultancy phase
- Equipment test phase
- Integration
- LS2 - Long Shutdown for accelerators upgrade works
- Fire Safety WPs dependence
- ALARA & radiation constraints



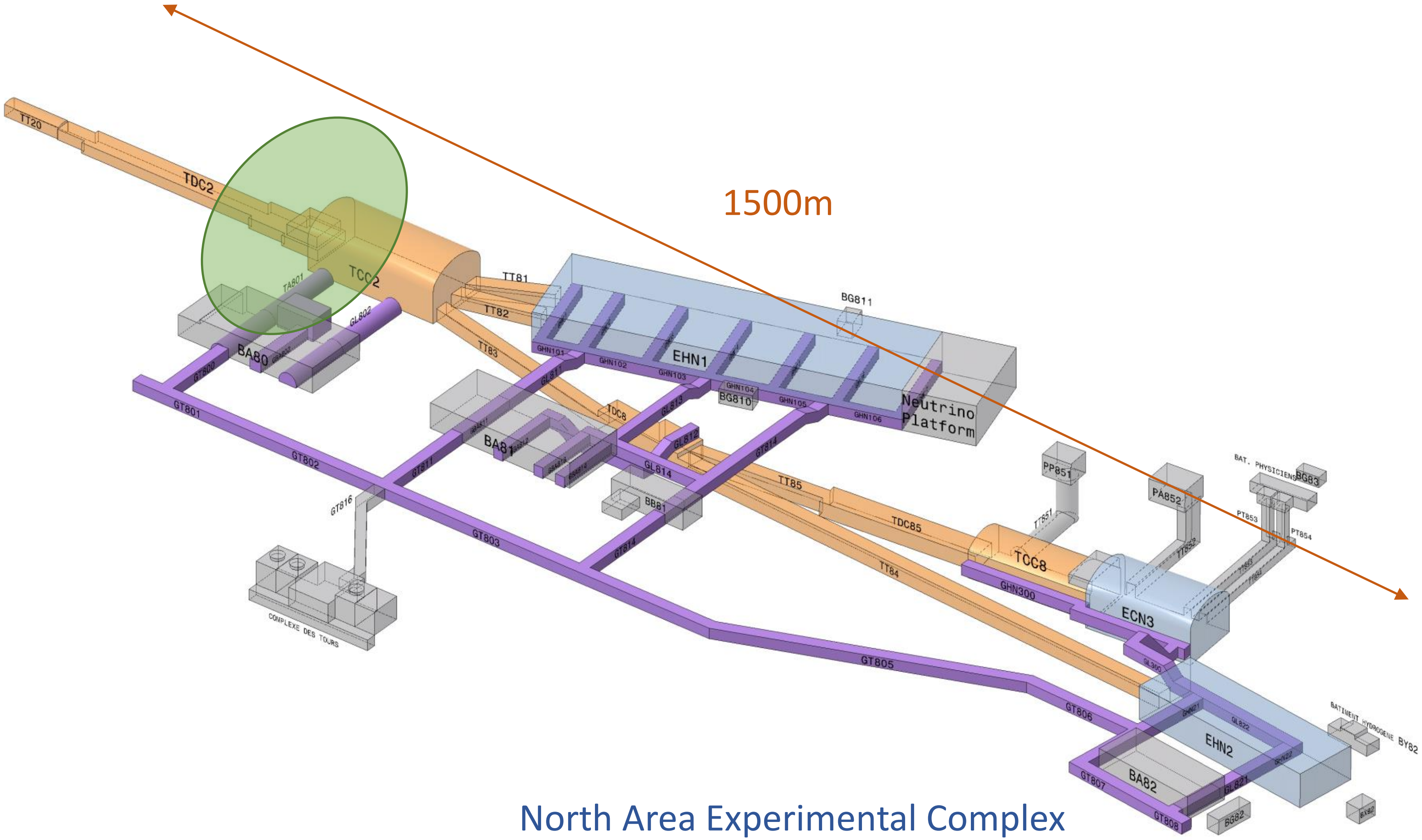




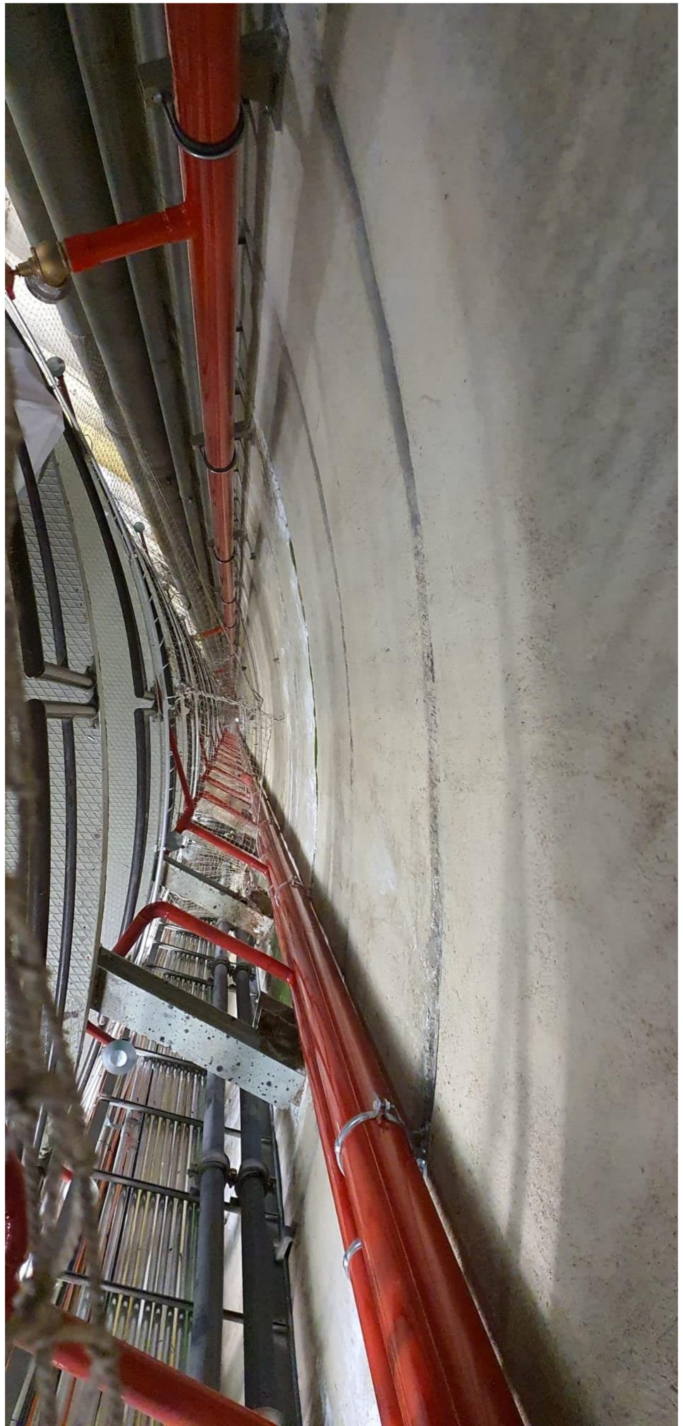
Agenda

- Introduction to CERN & the SPS
- SPS Fire Sprinkler Protection
- Next fire safety projects at CERN
- Conclusion

Next projects



North Area Experimental Complex



Conclusion

Conclusion

- The SPS Fire Safety study was essential to define the foundation for the fire safety consolidation projects at CERN
    - Safety concerns
    - Environment concerns
- Numerous Challenges
    - Conceptual
    - Integration
    - Radiation
- New or consolidation projects to start

Thank You.

Contact: Anna.Suwalska@cern.ch
www.cern.ch