SAFETY IN THE FCC FEASIBILITY STUDY

FCC Safety WG:

Thomas Otto, André Henriques, Oriol Rios, Ghislain Roy, Markus Widorski

CERN

Table of contents

- **CDR Achievements**
- **Safety Principles**
- **Putting the Principles in Action**
    - Identify Hazards and Risks
    - Reduce exposure to hazards
    - Beam safety and access
    - Robotics: Remote handling, Monitoring
    - Personal transportation: safe and rapid
- **Radiation Protection, Fire Prevention and Environmental Protection**
- **The FCC Safety Working Group**

CDR ACHIEVEMENTS

The CDR Safety Study had the purpose to show that a 100 km long accelerator can be operated safely in principle

No showstoppers, some results:

- Secure and safe accessibility of service caverns at all times
- Compartmentalization of tunnel
- Ventilation and smoke extraction scheme
- Tenability conditions for evacuating persons in realistic cases of fire and helium release
- Ionizing radiation environment allows access after suitable waiting time

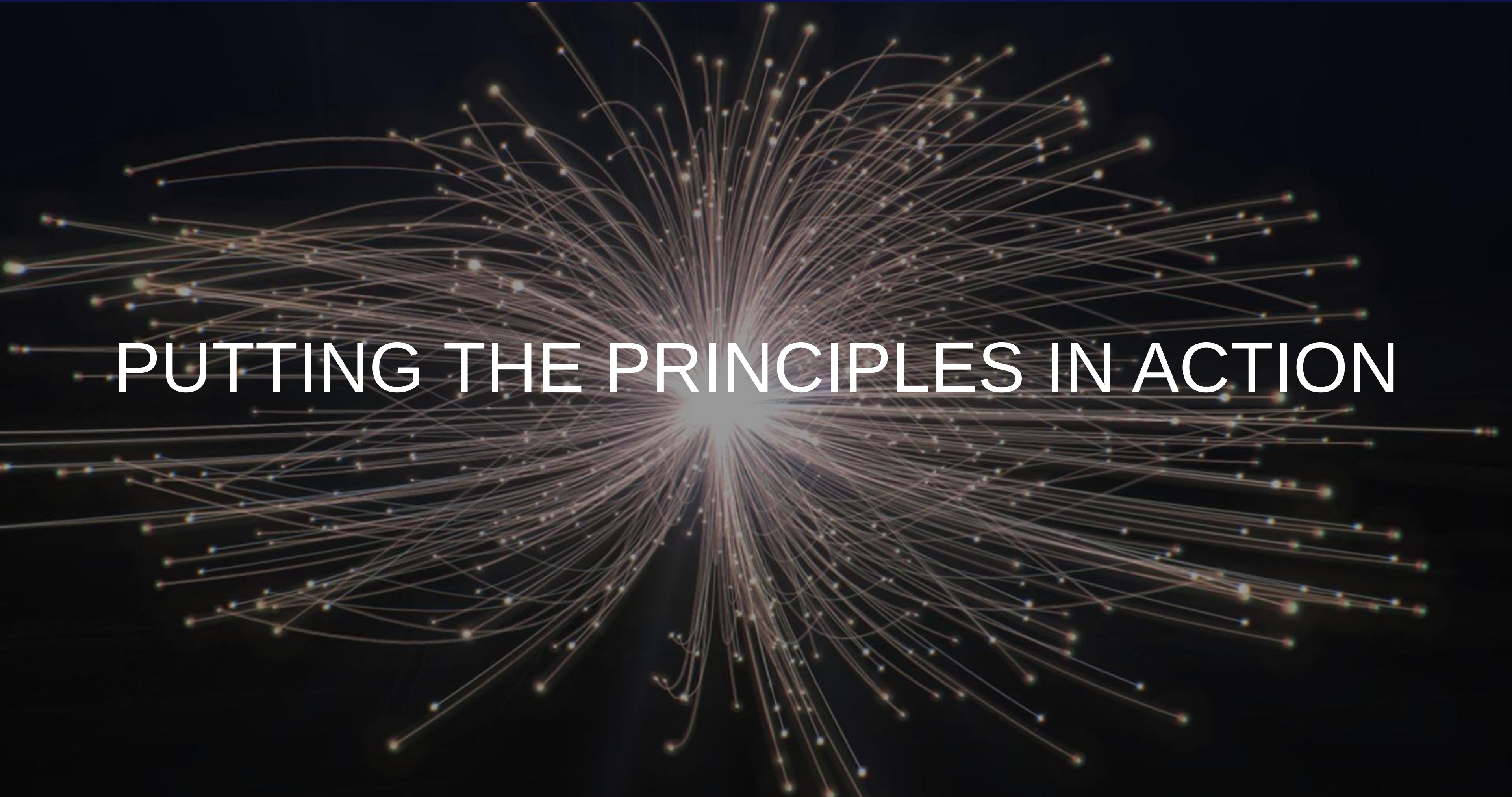
SAFETY PRINCIPLES FOR FCC

- **Identify hazards and analyse risks**

- Safety by design:
    - Eliminate the source of hazard
    - Wherever possible, select inherently safe technical solutions
    - **Reduce exposure to hazard**
    - Reduce the likelihood of accidents occurring
- Protect personnel and the environment
- Make use of performance-based-design when needed (quantifiable engineering design solution)

- **Infrastructure for FCC-ee must be compatible with highest hazard potential, usually from FCC-hh**

PUTTING THE PRINCIPLES IN ACTION



Identify Hazards and Analyse Risks

Feasibility Study Safety Report

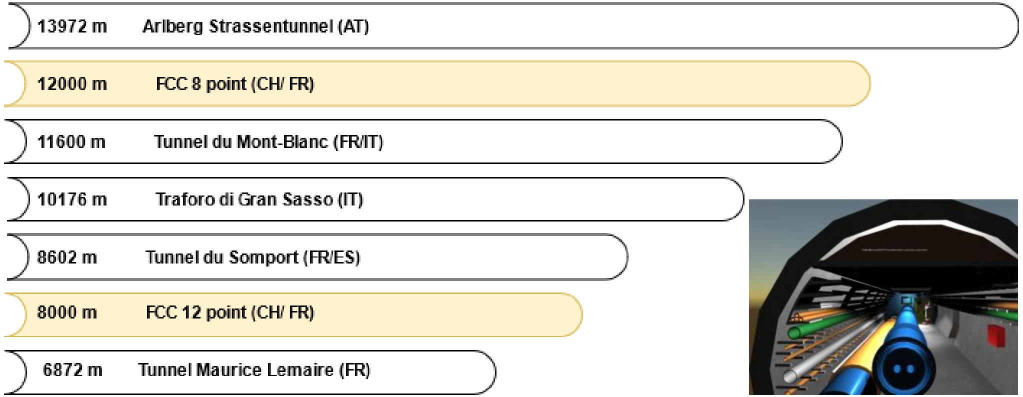
Wherever possible, refer to standard safety measures

Consultant help required for compilation of standard best practice

External Hazards
Physical Hazards
Ionizing and non-ionizing radiation
Noxious substances
Fire safety for occupants and emergency services
Electrical hazards
Operational safety (Beam safety and personnel safety)
Working conditions (incl. emergency response)
Worksite safety
Environmental protection

Reduce exposure to hazard

- FCC will have shaft depths of ≈ 300 m and intersite distances of 8 -12 km
- In the caverns and tunnels, personnel is exposed to:
  - Ionizing radiation
    Fire and ODH hazard
  - Physical injury hazard
- Extensive monitoring, avoid “blind spots”
- The less personnel in the underground, the better



Methods to reduce exposure:

- Beam Safety and Access
- Automatisation, remote manipulation, robotics
- Rapid and safe transportation
- Emergency forces have always access

Beam Safety and Access

Building upon the LHC accelerator safety and access control systems (LASS/ LACS)

- Care should be given to the layout of the underground structures, also in view of the sectorisation for access control, the localization of access points. This should be based on hazards and topology.

- Early identification of Safety Elements

- Early identification of access conditions based on identified hazards. (e.g. access and powering of magnets)


Beam Dump


Access Control

Remote manipulation / Robotics

Reduce exposure of personnel to hazards by increased use of remote technologies

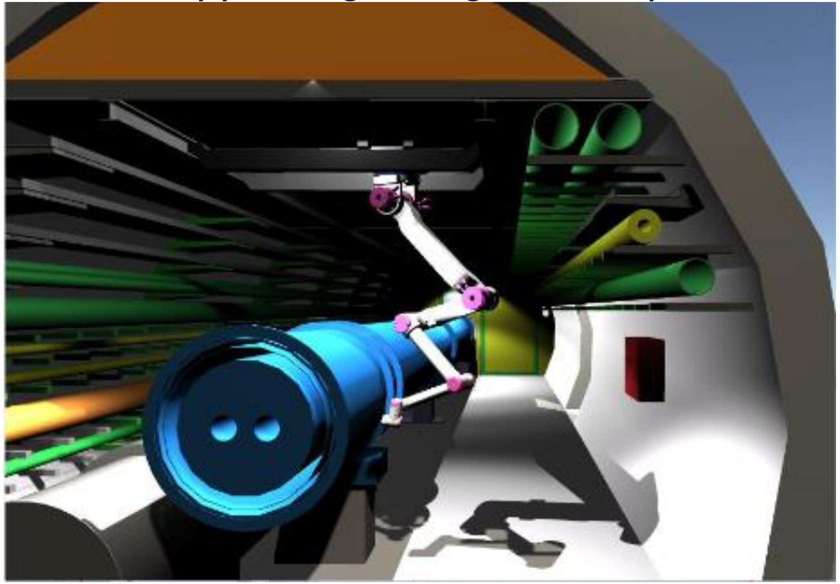
- For monitoring:
  - Monitoring of alignment, automatic re-alignment (evolution from HL-LHC)
  - Routine radiation surveys
  - Safety patrol before operation with beam
- For standard repair:
  - Transport of material (see below)
  - Exchange of normalized components
- For emergency intervention (already in CDR)
  - First-line fire fighting
  - Assistance during evacuation of personnel

The feasibility study should give enough room to such technologies, even if only speculative in 2021

Conceptual Robot from CDR

Rail-mounted to tunnel ceiling
(below smoke-extraction module)

Ok for monitoring and evacuation assistance
Cannot support high weight or torque



Direct Safety Support:
Fire brigade support
IR vision to find occupants
Carries fire-extinguishers

Transportation concept

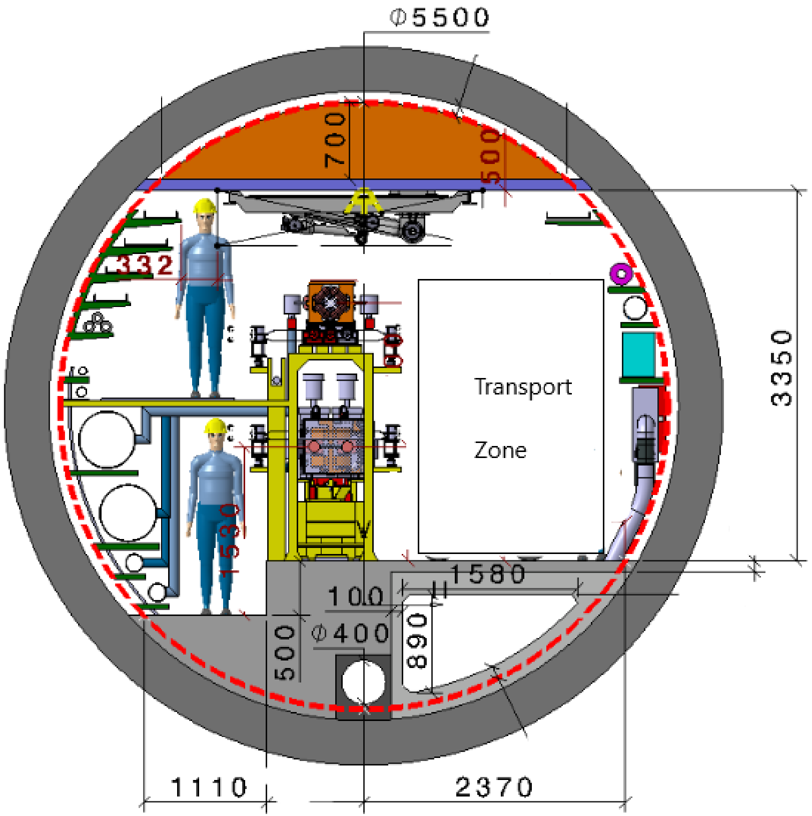
FCC is too large to simply extend the LHC transportation concept (on foot, by bike or slow electric vehicle)

FCC Transportation concept necessary

- for large loads (magnets) – treated in CDR
- **for personnel with small loads (maintenance)**

For safety purposes it has to include:

- A reasonable minimal speed
- Two-way traffic (safe encounters),
- Passage of compartment walls
- Emergency interventions (Fire brigade, ambulance)



Transport zone in ee-collider approx. 1600 mm wide
How to establish safe 2-way traffic ?

RADIATION PROTECTION
ENVIRONMENTAL PROTECTION
FIRE PREVENTION

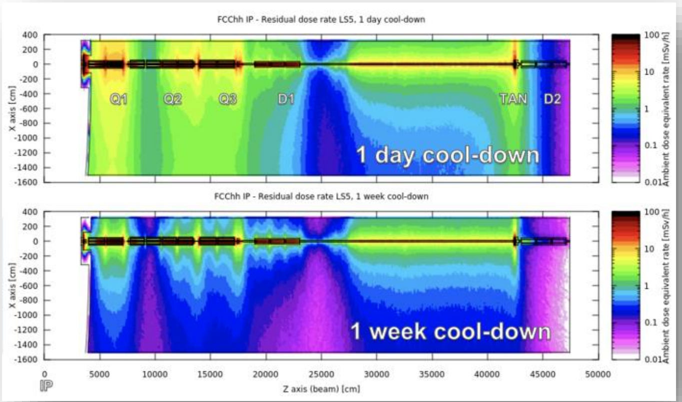
Radiation protection

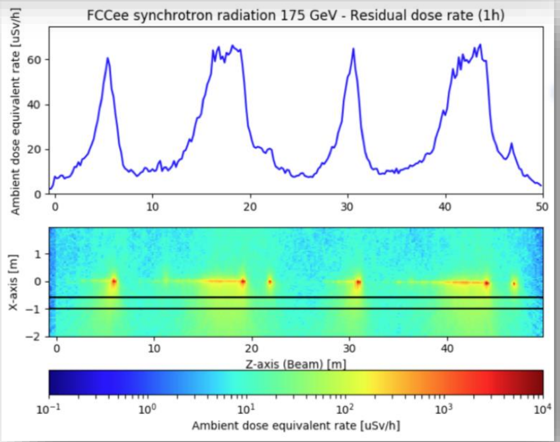
General considerations for the FCC Project

- Radiation protection by design for the (immutable) infrastructure must combine requirements for all FCC options, where FCC-hh will be most constraining.
- Civil engineering design decisions must reflect required installations constraints, especially for effluents management (water, air, coolants) and potential ground activation
- FCC-ee has particular topics which need to be addressed:
  - Synchrotron radiation and its activation potential
  - Access to klystron galleries during operation
  - Beam dumps
  - Positron production target

On-site impact (workers, operation, interventions material management)

- Evaluate and optimise design from civil engineering level down to individual items:
  - determine activation level → identify and integrate optimisation potential (material choices, option selection)
  - integrate adapted mitigation in the design of expected critical locations: collimation, dumps, interaction points, experiments/detectors
  - consider operational processes (maintenance, removal/installation, transport, storage, repair)



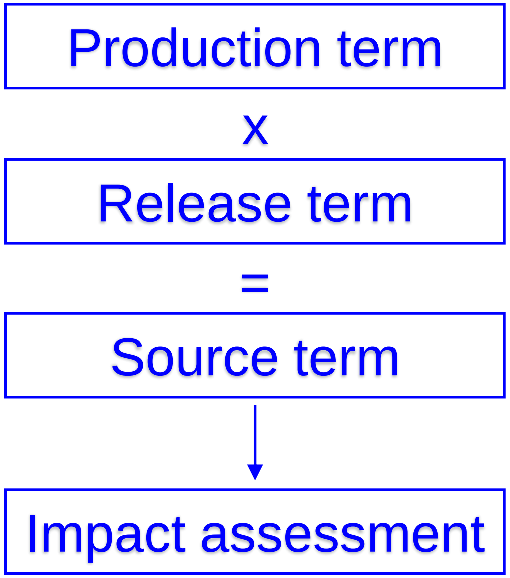


Off-site impact (environmental impact)

- Demonstrate legal compliance and obtain public acceptance
- Assess radiological impact on the environment during operation
  - Production terms: operation scenarios, beam parameters and loss scenarios
  - Release terms: optimisation of HVAC systems and civil engineering infrastructure

  = Source term (emissions) for environmental assessment

  → Impact assessment: Dose assessment for representative person and comparison to dose objectives, constraints and limits.
- Demonstrate efforts for radioactive waste reduction
- Assess radioactive waste production, describe management and disposal



Environmental protection

Environmental impact assessment:

- In the “Host State processes and civil engineering”-pillar of the study

Based on this assessment

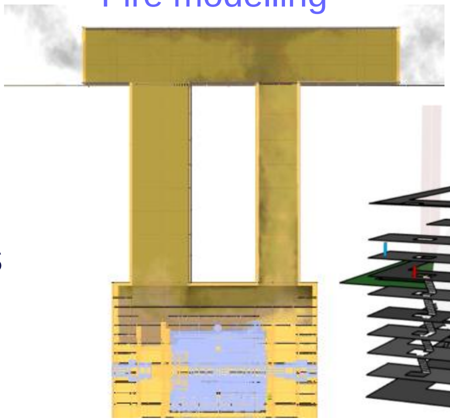
- Devise technical means to minimize emissions (e.g. retention basis, sound-proof walls)
- Develop an environmental monitoring program (for radiological and “conventional” releases)
- Propose strategies for accidental release response

FIRIA – Fire-Induced Radiological Integrated Assessment

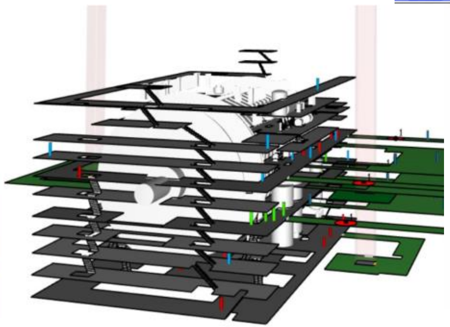
Study the impact that an accidental fire has on the release of radioactive substances

- Burning organic material
- Smoke and soot transport
- Extinguishing and intervention ops
- Mitigation measures
- Example : ISOLDE / ATLAS

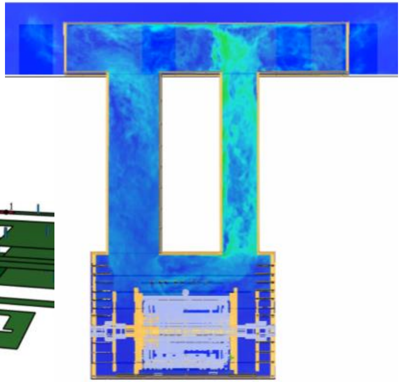
Fire modelling



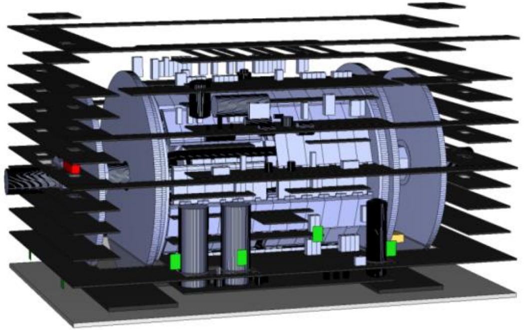
Egress modelling



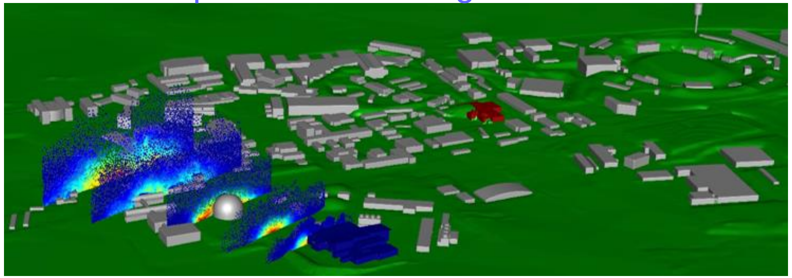
Aerosol modelling



Fire scenarios identification



Outdoor dispersion modelling



Courtesy: FIRIA team (S. La Mendola et al.)


CONNECTIONS
COLLABORATIONS
PERSONNEL

Work packages with impact on safety

Physics and experiments	Accelerators	Technical Infrastructures	Host State processes and civil engineering	Organisation and financing models	Study support and coordination
Physics programme	ee & FEB design	Electrical infrastructure	Administrative processes	Organisation model	Study/collaboration secretariat
Detector concepts	hh design	Cooling & ventilation Cryogenics	Placement studies	Financing model	Study support unit
Physics performance	Technology R&D	Transport and logistics	Environmental evaluation	Procurement strategy and rules	EU projects
Software and computing	ee MDI	**Safety**	Tunnel, subsurface design	In-kind contributions	Collaboration building
	ee injector	Technical Infrastructure Operation	Surface buildings design	Operation model	Communications
		Geodesy	Landplots and access		

Looking forward to fruitful collaboration

Collaborations

FCC Fire Collaboration

International network of Fire Safety set during CDR phase with experts from several particle accelerator facilities and physics laboratories.

Aim: to share best practice, state-of-the-art working solutions and peer-review fire safety features.

BERKELEY LAB
Fermilab
ess EUROPEAN SPALLATION SOURCE
JÜLICH FORSCHUNGSZENTRUM
LUND UNIVERSITY
DESY
MAX IV
BROOKHAVEN NATIONAL LABORATORY

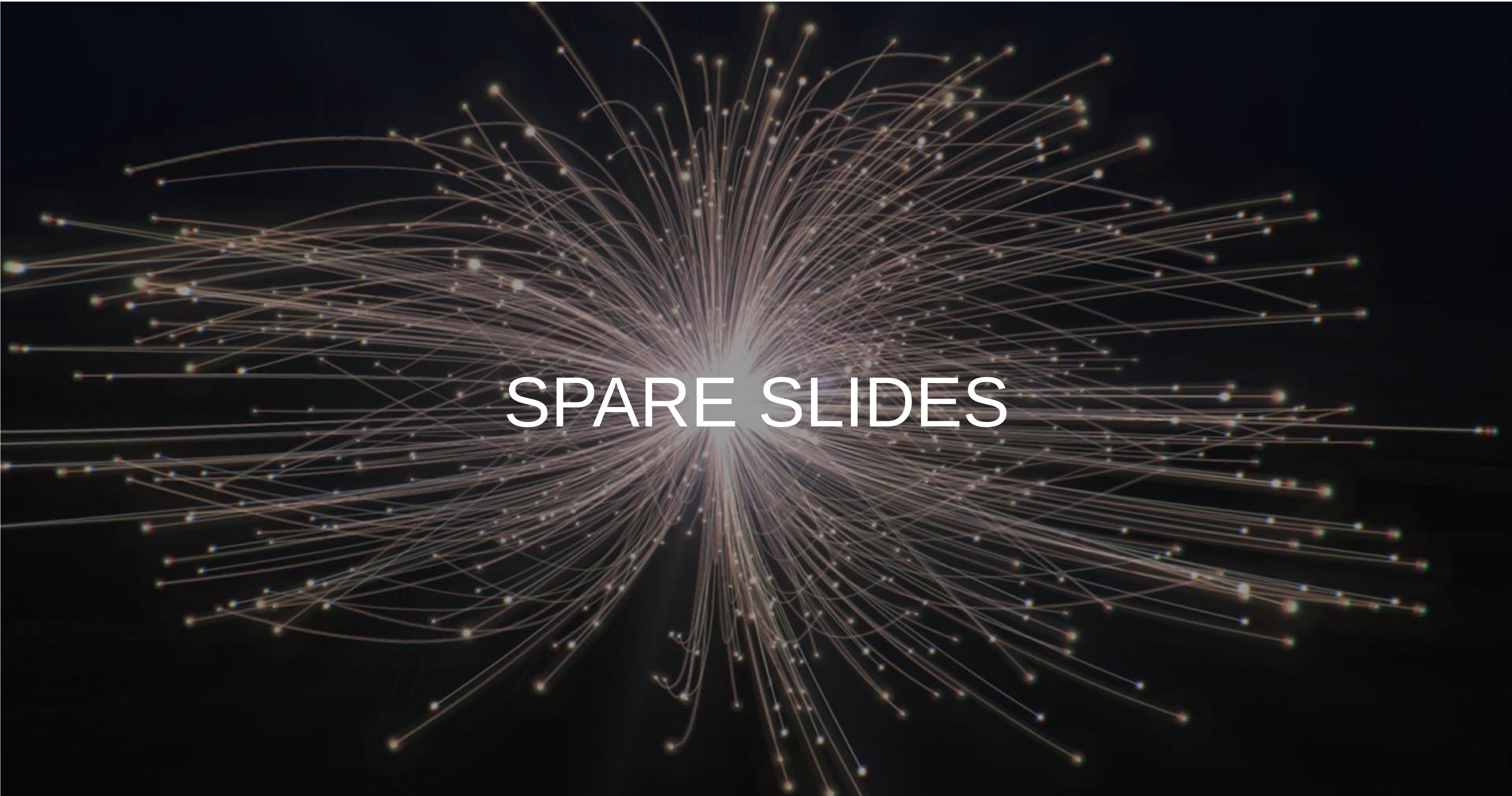
The FCC Safety Working Group

Core Team (2021):

Thomas Otto	ATS-DO	Study coordination, editor
André Henriques	HSE-OHS	Occupational health and safety
Oriol Rios	HSE-OHS	Fire and emergency response
Ghislain Roy	BE-ABP	Operational safety, personnel safety systems
Markus Widorski	HSE-RP	Radiation protection
N.N.		Environmental Protection

Safety-minded individuals from the wider collaboration are invited to join us and work on specific topics

Thank you
for your attention.



SPARE SLIDES

Scope

Safety for the FCC Feasibility Study comprises:

- Occupational health and safety
- Radiation protection
- Beam- and access safety
- Emergency response
- Environmental monitoring

It does not include

- Machine protection