Optimisation of radiation exposure at CERN’s accelerator complex


Abstract

Managing occupational exposure around particle accelerators is challenging, not only due to the wide range of nuclear technologies and radioactive sources, but also due to large number and different background of intervening personnel, as well as to the continuous change affecting the work-places.

Introduction

- RP regulations based on most advance practices in CERN’s Host States, i.e. France and Switzerland apply at CERN [1];
- Implementing these regulations at CERN has many specific aspects due to the complexity of the high energy physics involved and the size of the installations (>50 km of tunnels);
- Ambient dose equivalent and environmental monitoring has to take into account the fast pulsed time structure of the prompt radiation, sometimes in high magnetic fields;
- Competence in high-energy physics and related scientific tools, as well as monitoring of a large number of (non-residential) individuals (e.g. visiting scientists) are mandatory;
- Specialized engineering and choice of materials is vital which sometimes have to operate in extreme conditions often intercepting high-intensity particle beams.

Radiological risks at CERN

High-energy particle beams interact with matter to generate high energy secondary radiation of mixed nature and to produce radioactive material.

Area Classification

In order to manage radiological risks, buildings and areas at CERN are classified according to the degree of radiation hazard during "beam-on" and "beam-off" conditions.

Optimization rules and procedures

Legislations usually relate to nuclear power plants or similar installations, thus intrinsically have certain shortcomings when applied to high-energy accelerators.

Based on French and Swiss legislation and tailored to the complexity of CERN’s accelerators, an ALARA approach has been developed. [2]

For all work to be performed in Controlled Areas, different security levels in combination with so-called trigger values are suggested. [3]

One practical case: the HiRadMat Project

HiRadMat (High Radiation to Materials) [4] is a new facility under construction at CERN/SPS which aims at investigating the behaviour of materials at the impact with high-energy and high-intensity pulsed beams. CERN is presently decommissioning the WANF (West Area Neutrino Facility) to allow the installation of the new irradiation area. The WANF dismantling is a controlled area, a worksite and two level 3 ALARA Committees were held in order to optimize the dose to personnel. The initial budget dose of 210 mSv was reduced to 60 mSv by improving handling means (automatic hook for shielding block handling, remotely controlled crane), by producing detailed and highly optimized work procedures (including use of mock-up, simulations and preliminary tests) and by personnel training.

The application of the ALARA principle have been integrated in the design of the future irradiation area. The remnant radiation levels were predicted using FLUKA [5] simulations: 50 mSv/h at contact directly after the beam is stopped in a block of matter as used for the LHC collimators. The radiation levels rapidly decrease when the beam is stopped, however to allow access for people a ventilation scheme with fast air flushing via active filters is implemented. The access control system and on-line radiation level monitoring of the irradiation area were conceived according to the CERN radioprotection rules and industrial best practices.

The design of the facility takes into account operation respecting the ALARA approach. The three test stands are fully equipped with plug-in connectors in order to be handled by the remote controlled overhead crane (embedded + steady cameras). To reduce installation, maintenance and decommissioning time, prefabricated equipment is used as much as possible as well as extra long-life lights.

Lessons learned

- In high-energy accelerators, extended regions can show elevated residual activation;
- These accelerators require a high degree of flexibility in operation and maintenance; only specific guidelines can ensure that a high level of performance is achieved still applying a high safety standard;
- ALARA optimization for all work performed in Controlled Areas requires complex dose evaluation and work-planning closely linked to technical and administrative implementation of operational dosimetry.

References

[2] L’approche ALARA au CERN, Consignes Generales de Radioprotection, Instruction Generale de Securite S5-GSI1, D.Forkel-Wirth, EDMS No. 515123, Revision 2006, CERN.