UNI STUTTGART

Reliability Department

# Reliability assurance of safety-critical systems at CERN


## Motivation

The European Organisation for Nuclear Research (CERN) uses particle accelerators for experiments in high-energy physics. High amounts of energy are stored in the beams and superconducting magnetic circuits generated during operation, which can be released in an uncontrolled manner and cause catastrophic damage. This can happen, for example, when a quench occurs, a local temperature increase in a magnetic coil that leads to the loss of superconducting properties (see Fig. 1). In order to safely extract these energies, highly reliable protection systems are required that are confronted with new challenges in reliability protection, such as the increasing shift of critical functions to programmable units (e.g. FPGAs).

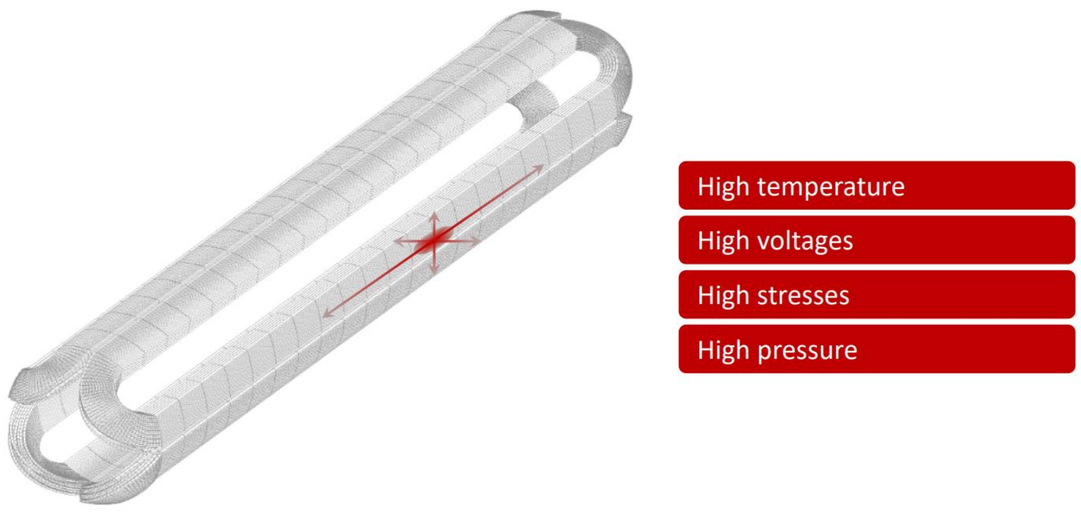


Figure 1: Quench [1]

## Procedure

At the beginning of the project, reliability analyses for systems such as the Universal Quench Detection System (see Figure 2), which is required for the detection of a quench, will be carried out using the established workflows and reliability assurance methods (FMEA, etc.). Subsequently, new reliability assurance methods will be explored to better incorporate process and non-hardware related factors into the analysis. In addition, it will be investigated how test data from predecessor systems or current systems can be integrated into the reliability assessment in the best possible way. Based on the existing procedures and new research results, a reliability assurance guideline will be developed.

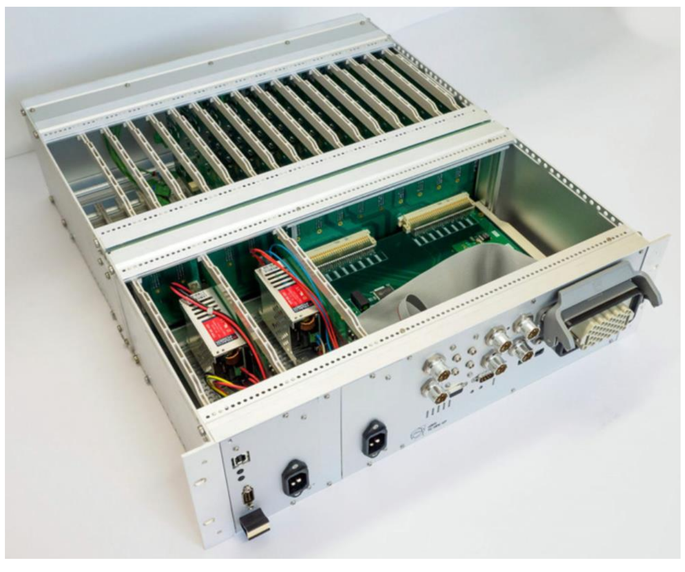

Figure 2: Universal Quench Detetction System (UQDS) [2]

## Objective

Development of a guideline for the reliability assurance of safety-critical systems produced in small series and consisting of hardware and software.

**Sources:**

[1] E. Ravaioli, “Energy Shift with Coupling (ESC): a new quench protection method“, CERN, Meyrin, Switzerland, July 2024. [Online]. https://indico.cern.ch/event/1429250/contributions/6012523/subcontributions/489664/attachments/2887388/5060964/ESC_TE-TM_Ravaioli_20240701.pdf

[2] R. Denz *et al.*, “Quench Detection and Diagnostic Systems for the Superconducting Circuits for the HL-LHC”, in *Proc. IPAC'19*, Melbourne, Australia, May 2019, pp. 4183-4186. doi:10.18429/JACoW-IPAC2019-THPTS036

## Cooperation with:

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