Abstract
The LHC RF cryomodule “Asia” suffered an accidental influx of about 0.5 l of tunnel air during the leak checks of the pumping manifolds. The resulting risk of particle contamination was difficult to assess, and could not be excluded with certainty. If one or more cavities were contaminated, a severe impact on beam operations in the LHC machine was to be expected. In order to minimize the risks, the Asia cryomodule has been replaced with a spare unit. Subsequently, the cryomodule was tested in the SM18 test facility without intermediate venting, and showed high levels of radiation due to field emission above 1.8 MV in one of the cavities. The other cavities were less strongly affected, but clear signs of contamination were observed. The helium processing technique was used to improve the performance of the SRF cavity with respect to field emission.

Introduction
The LHC RF cryomodule contains four single-cell niobium coated 400.8 MHz superconducting cavities working at 4.5 K and an average accelerating voltage of 2 MV per cavity. The accelerated beam enters the module through cavity D.

In the course of the ongoing long shutdown, LS2, the LHC RF cryomodules underwent consolidation works.
• During the leak checks of the pumping manifold (near the cavity A), the RF cryomodule (Asia) suffered an accidental influx of about 0.5 l of tunnel air, giving a pressure spike of 0.65 mbar.
• Therefore, it was decided to replace it with the operational spare unit (America).

The replacement took 10 weeks and the Asia cryomodule was transported under vacuum to CERN’s SM18 test facility and prepared for the cold test.

Helium processing
The helium processing technique has been used at CERN for many years. However, was not frequently used for fully equipped modules.

Challenges and risks:
• The cavity vacuum level during He processing is much higher than the vacuum interlock level normally set during RF conditioning.
• He gas pressure must be enough to create a plasma, but not too high (risk of breakdown).
• Installation and operation of vacuum devices and gases in the cold environment.

Settings:
• 1hour, 10 ms pulse length and 50% duty cycle at 2.5 MV
• Pressure: 1.4×10−5 mbar

Results:
• The level of radiation at 2.4 MV was reduced by 85% and the onset of field emission was moved ~2 MV.
• These results were confirmed after a thermal cycle.
• The cavity was able to work stable for several hours at 2 MV without observing any increase in radiation, temperature, nor quenches.

Conclusion
• Clear signs of contamination were observed in one LHC RF cryomodule, after the accidental venting occurred in the LHC tunnel.
• The performance of the most severely affected cavity, the D cavity, could not be restored by RF pulse processing.
• Therefore, the helium processing technique has been used, which successfully improved the performance of the cavity with respect to field emission, and allowed to requalify the cryomodule as a valid spare.

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