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Mitigation of Radiation and EMI effects on the Vacuum Control System of LHC

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The 26 km of vacuum chambers where circulates the beam of LHC (Large Hadron Collider) must be maintained under UHV (Ultra High Vacuum) to minimize the beam interaction with residual gases, and allow the operation of specific systems. The vacuum is measured by several thousands of gauges along the accelerator. Bad vacuum measurements may trigger a beam dump and close the associated sector valves. The effects of radiation or EMI (Electromagnetic Interferences) on components that may stop the machine must be evaluated and minimized. We report on the actions implemented to mitigate their impact on the vacuum control system.

Summary

The electronics of the vacuum control system are mainly located in the service areas. These underground areas are isolated shielded from the tunnel where the beam travels. Particle interactions with residual gases, collimators, and or other equipment (e.g. due to beam instabilities) are the source of ionizing radiation, with a rich and varied energy spectrum. With the rising of LHC's energy and intensity, some service areas have become too much exposed to these radiations, despite the available shielding, and can lead to malfunctions due to SEE (Single Event Effects). This resulted in an increase of equipment failures leading to beam dumps, which are time expensive for the machine operation. During the last runs of 2012, switching power supplies in valve controllers were destroyed; blocking of PLC (Programmable Logic Controller) CPUs (Central Processor Unit) were observed, most probably due to radiation-induced effects.

A shielding and relocation project was already born in 2010 to mitigate these types of events for the LHC at higher energies and intensities. During the LS1 (first long shut down), the vacuum control system will be mainly concerned in point-7 of the LHC: over 27 racks will be relocated and 350 cables must be extended into the new safe area; new features will be added, such as remote reset for slave PLC. This project will require the complete shutdown of vacuum controls for more than a year, during the dismantling activities; the NEG (Non-Evaporable Getters) activation and the bake-out of the vacuum chambers will require a minimal local control system to meet the established schedule of the LS1.

Some equipment is installed in the tunnel, without any shielding, and are subject to ionizing radiations, with a level depending on the location. The vacuum in the arcs is currently measured by active gauges, providing an analog signal 0-10V sent along twisted pairs to the PLCs installed into the protected areas. In order to better understand their tolerance, a test under radiation will be performed. Furthermore, a new and more accurate active gauge is under evaluation: it is also planned to be tested under radiation to evaluate the probable life time with an increasing beam energy and intensity.

Radiation is not the only source for disturbance or system failures: the electromagnetic environment in the tunnel and service areas is rich in interference sources. Given the dimensions of the machine, long cables are required to connect the instrumentation to the controllers; ground loop and coupling issues can easily become annoying and should be avoided, especially when signal levels are very low. A study to reduce measurement noise on ionization gauges was conducted: the first steps were applied during the 2012 winter technical stop. All the triaxial cables have been tested and repaired where necessary. A filter has been introduced in the shielding, to reduce coupling on the central conductor. The modification of the electronics in the controller was also conducted during 2012, to center the measure and make a better filtering before sampling to be less susceptible to electromagnetic interferences.

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