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Future Robotic Residents in Experimental Caverns

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EP-R&D WP4 Robotics for Detector is devoted to introducing robotic systems in future high energy physics experiments to assemble, maintain, inspect, and operate particle detectors. The harsh cavern environment constitutes a challenge for these systems, which will have to deal with high radiation levels and magnetic field intensities. The first step to reach this goal is to deploy these robots for cavern inspection, alarms verification, and environmental mapping during beam run. To this end, several mobile platforms with specific payloads have been identified. Both ground and aerial solutions are currently being developed.

Quadruped robots have been recognized as a suitable solution for ground inspection tasks, for their agility and capabilities to climb intricated ladders and steps. The mobility and controllability of these quadrupeds have been successfully tested within the detector cavern. Moreover, the tested robot was also able to withstand relatively weak magnetic field intensities.

Furthermore, we are investigating the use of a swarm of small quadruped robots (few centimetres in size) specifically designed for inspecting confined and cluttered spaces, aiming at detecting leaks or anomalies in between intricate detector services that have triggered alarms. Within these areas, CERN network is usually unavailable; therefore, a mobile mesh network protocol is under development to guarantee an uninterrupted and efficient communication within the swarm and between the swarm and the remote operator.

To complement our ground-based inspection, we are developing autonomous flying vehicles, such as blimps, equipped with sensors for an accurate aerial environmental mapping of the detector cavern. A blimp prototype has already been designed and tested in collaboration with Windereiter. The software incorporating guidance, navigation, and control algorithms is currently under development, and focus is given to magnetic disturbance rejection.

In parallel with the cavern inspection, we are working on developing robotic-friendly particle detectors integrating interfaces for quick and controlled interactions between detector and robotic systems. In this framework, an innovative design concept for an automatic detector modules insertion/extraction has been proposed and will be further developed, using the future ALICE 3 detector as reference.

The employment of the aforementioned robotic solutions promises to streamline the processes, reduce personnel exposure to radiation, and increase the beam run time, improving both safety and efficiency.

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