A NOVEL QUALITY ASSURANCE ROBOT FOR RF CAVITY INSPECTION SYSTEM

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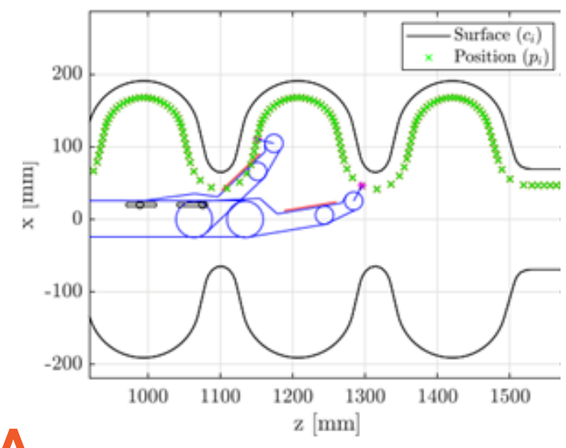
Abstract: Radiofrequency cavities are critical for accelerating beams at CERN, and their efficiency is in part due to the inner surface quality, which may be effected by various mechanical procedures such as welding. A detailed inspection is required to ensure the quality of manufacturing, but also for post mortem analysis. Ideally, this inspection should be non-destructive, and a new robotic system has been developed at CERN to perform this task. The Automated Robotic Inspection System (ARIS) autonomously meets, for the first time in the world, the needs of CERN to visually inspect the entire inner surface of radiofrequency (RF) cavities in LHC, Linac and FCC, and to detect any anomalies at short distance. This system is equipped with a liquid lens able to overcome depth of field (DOF) limitations, a high-resolution camera which ensures excellent quality photos regardless of the distance within the entire cavity, and an anti-collision mechanism that can immediately stop the inspection system, if required. ARIS is capable of performing three different scan modes in three different cavity types through a specialised user interface currently in development. This system is controlled using the CERN Robotic Framework - a robust software framework that is modular and used on all CERN inhouse robotic platforms.

Trajectory Generation

Requirements:

- Constant camera working distance (23 mm)
- Camera position at normal incidence to image point
- Each photo taken has to have 30% of overlap between each other

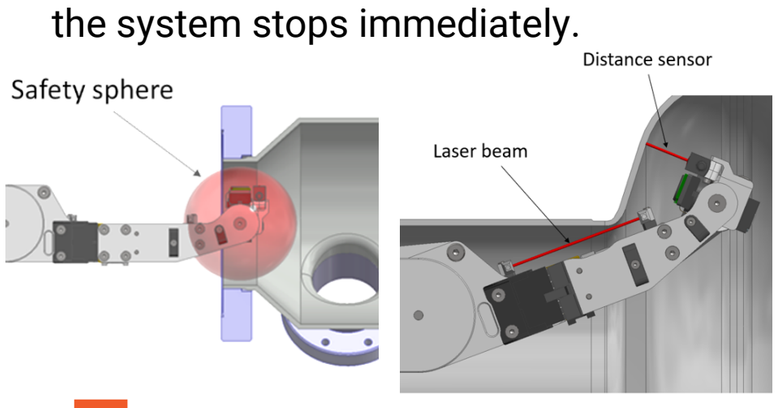


Anti-collision system

To safely scan a cavity without colliding with it, the arm is equipped with:

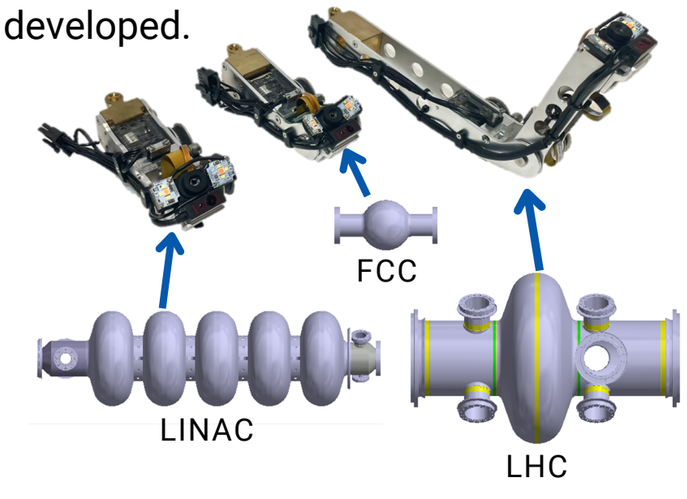
- a distance laser located below the camera
- a laser beam located on the main arm's length

If any of these two lasers are triggered the system stops immediately.



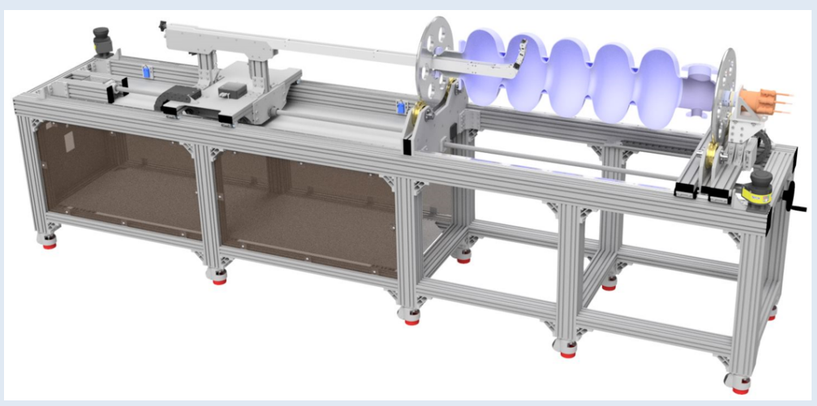
Three cavity types

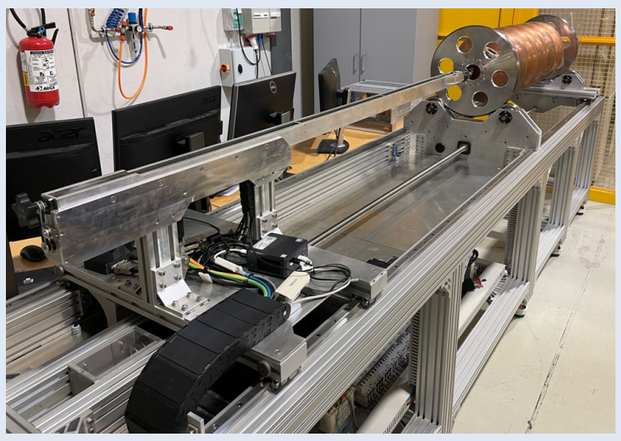
To inspect the three cavity types - which all have different dimensions - three optimized arms lengths have been developed.



SYSTEM

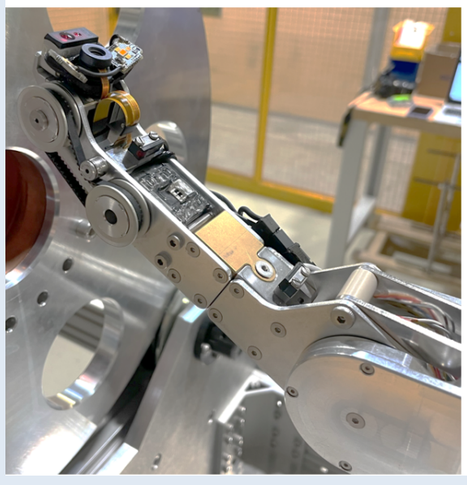
ARIS autonomously meets the needs of the SY-RF group at CERN to visually inspect inspect the entire inner surface of radiofrequency (RF) cavities in LHC, Linac and FCC, and to detect any anomalies at short distances in a safe manner. So far, no commercial and custom systems on the market have addressed both issues which makes this system unique.

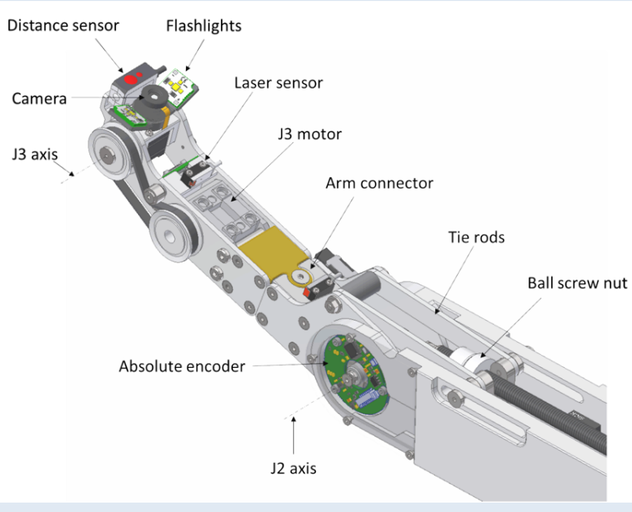




ROBOTIC ARM

The three degrees of freedom robotic arm is equipped with many components which allow it to perform a safe cavity inspection.





VISION SYSTEM

The vision system is composed of three main components:

- **A liquid lens**: The focus is achieved by varying the by varying the applied voltage on the lens.
- **A high-resolution miniature camera**: This 18Mpix (15x15x8 mm) camera takes pictures of sizes around 12x16 mm with a pixel size of 1.25 um which allows a high resolution on the surface quality (4896 x 3680 px).
- **Flashing LEDs**: Two LEDs of 314 lumens each are fixed near the camera objective and are triggered each time a photo is taken for a variable exposure time [0.5 – 1.5] ms.