Activity 2: Interfaces of future detectors for Robotic and Automatic Systems

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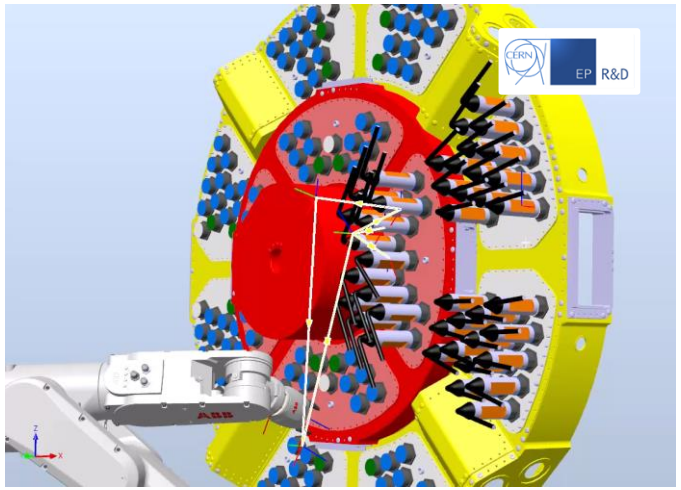
On behalf of WP4

https://indico.cern.ch/event/1063927/

GOAL OF THE ACTIVITY

TWO BENEFITS OF AUTOMATION AND ROBOTIZATION:

- **TIME OPTIMIZATION, less time is spent for maintenance more time available for physics**
- **SAFETY, reduced need to send personnel in radiative environment, dose saving**



GOALS OF THE ACTIVITY

- **Developments of guidelines for the design of interfaces between future detector and robotic/automation systems**
- **Conceptualization of the robotic/automated systems to make them work into the detector environment (with radiation and magnetic field background).**

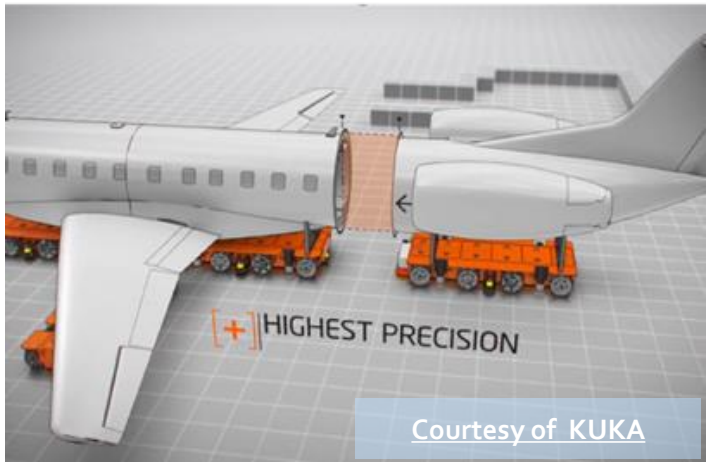
More detail on EDMS documents 2588887 and 2632093

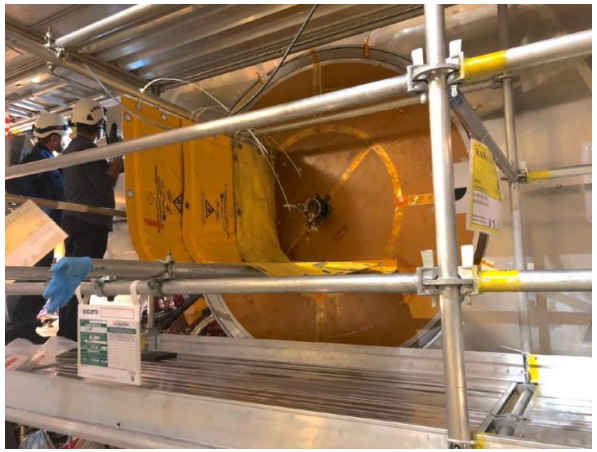
Potential use-cases requiring design on the detector-robot interfaces:

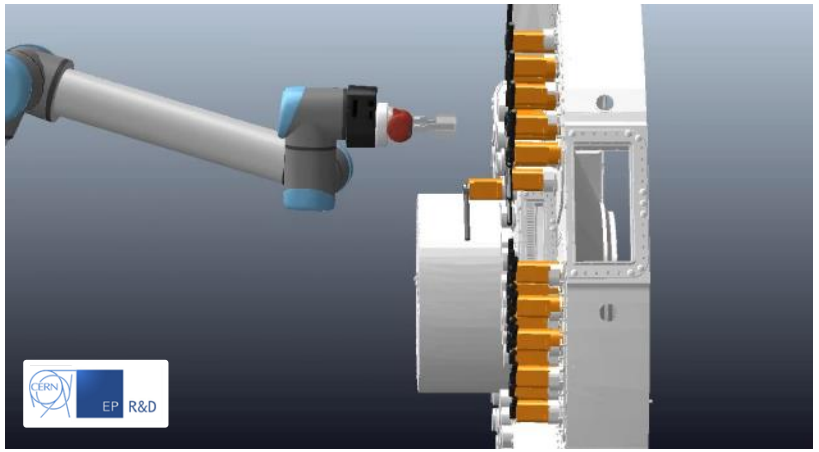
Automated detector opening and insertion of radiation shields

Robotized service disconnection

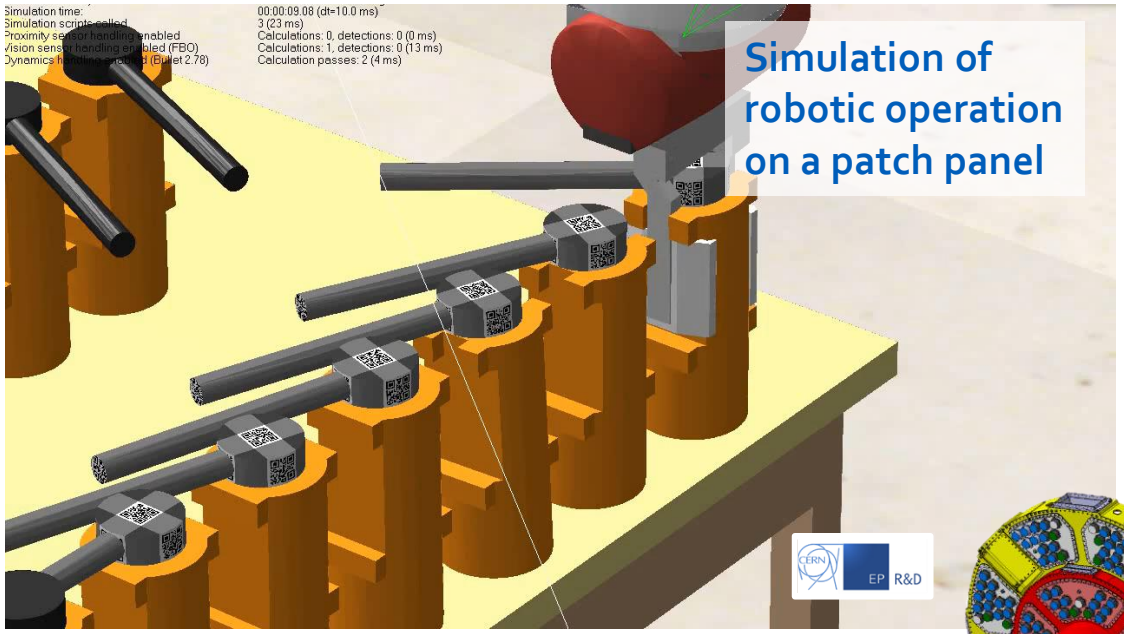
Tracking detector Insertion and extraction

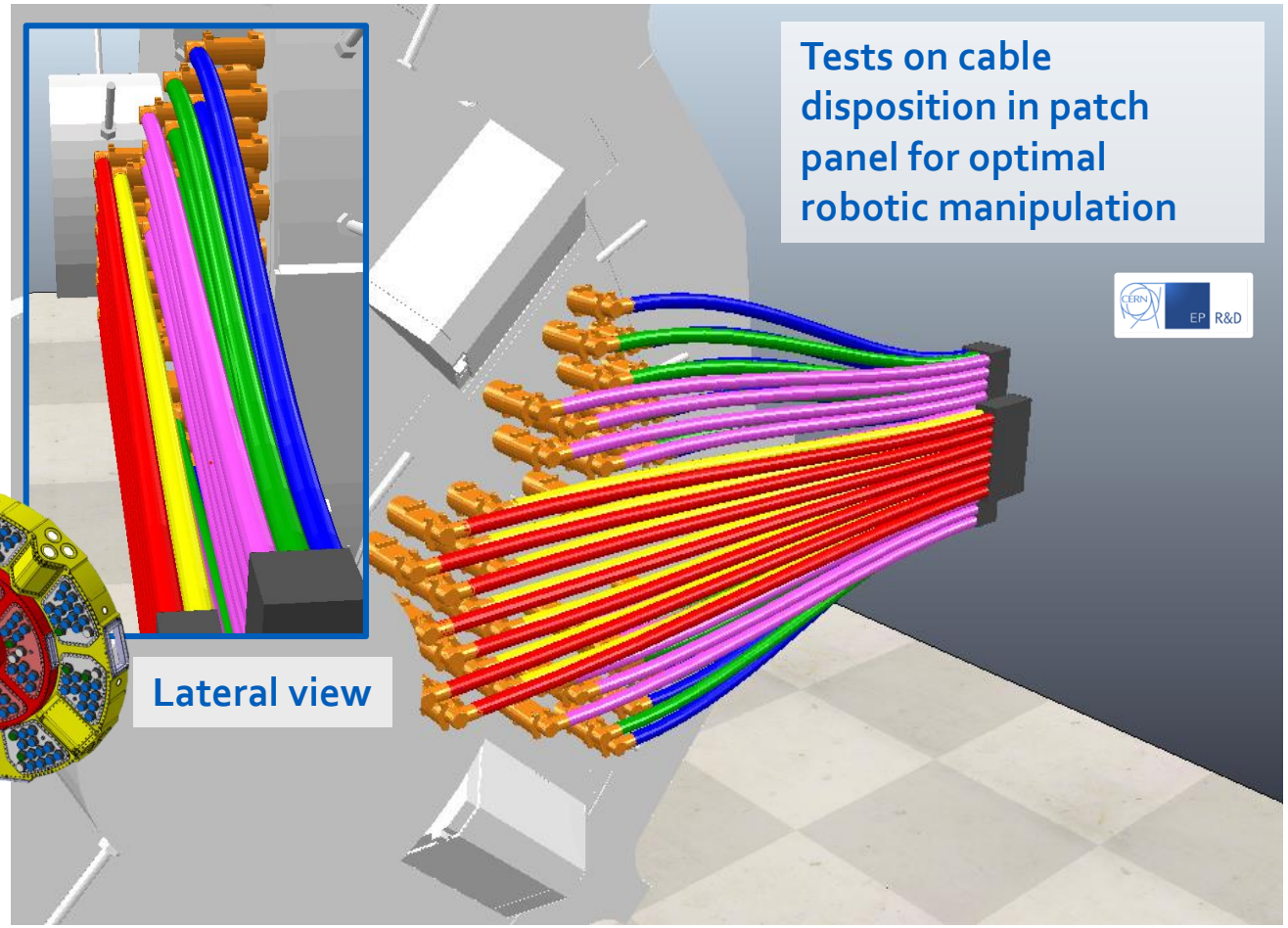


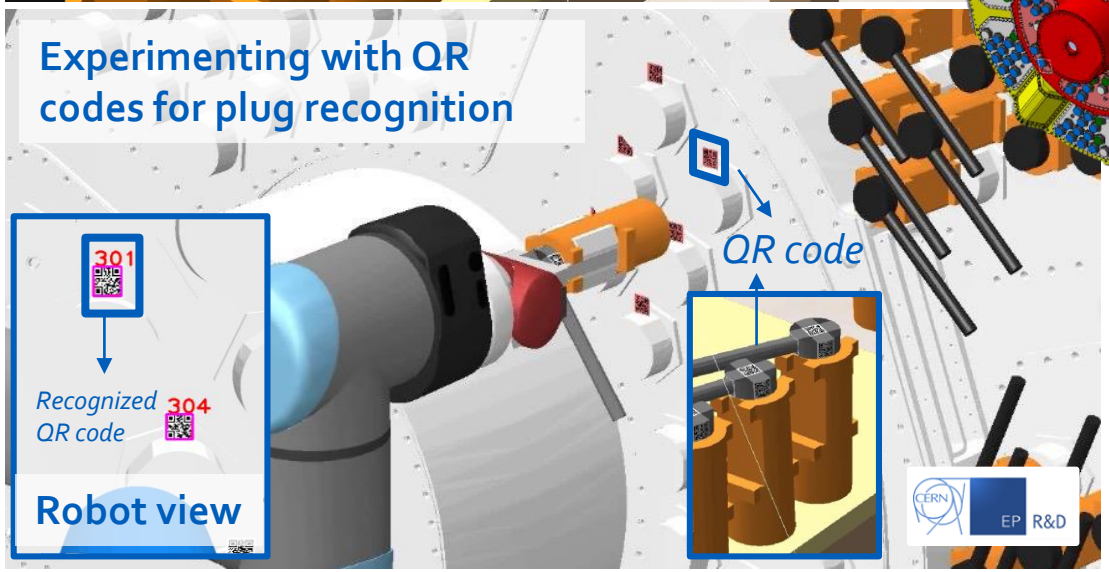




ROBOTIZED SERVICE DISCONNECTION







Optimization of the connector design to be manipulated by a robot
Tests on the effective manipulation (both kinematics and dynamics)
Tests on cable disposition in patch panel for optimal robotic manipulation, cable direction, gripping orientation.

Potential use-cases of robotics platforms: regular inspections and fault detection also in very confined, inaccessible, highly radioactive detectors' areas




QUADRUPED ROBOTS FOR DETECTOR'S CAVERN INSPECTION

ANYbotics, ANYMAL C MOVING AUTONOMOUSLY ON STAIRS

Boston Dynamics SPOT

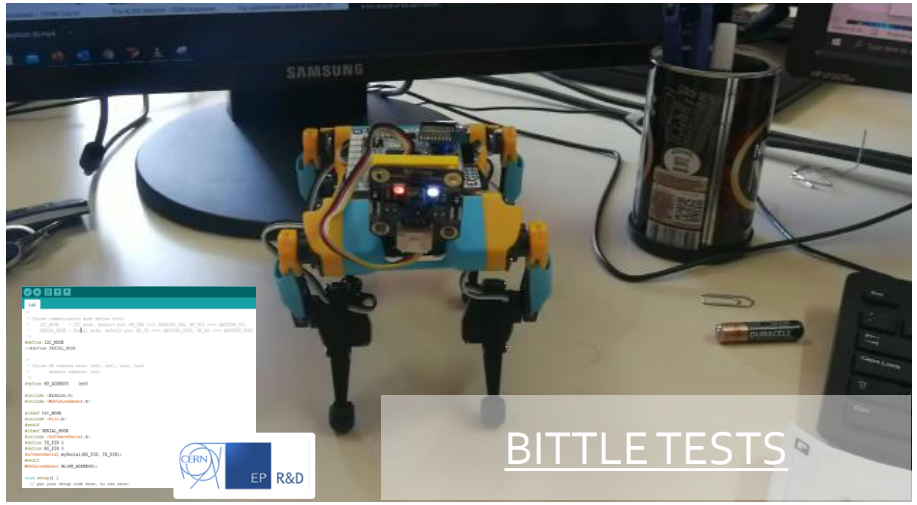
ANYbotics Visit in the ALICE experiment, ANYmal D in the CAVERN

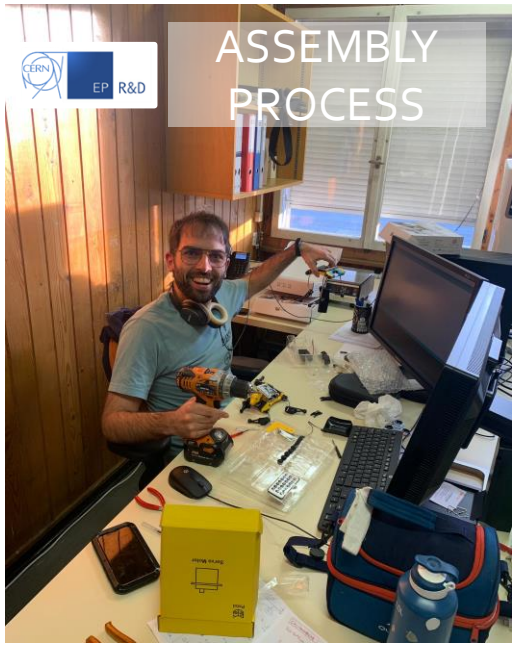
RADIATION MEASUREMENTS SPOT

TOOLS TO MEASURE RADIATIONS

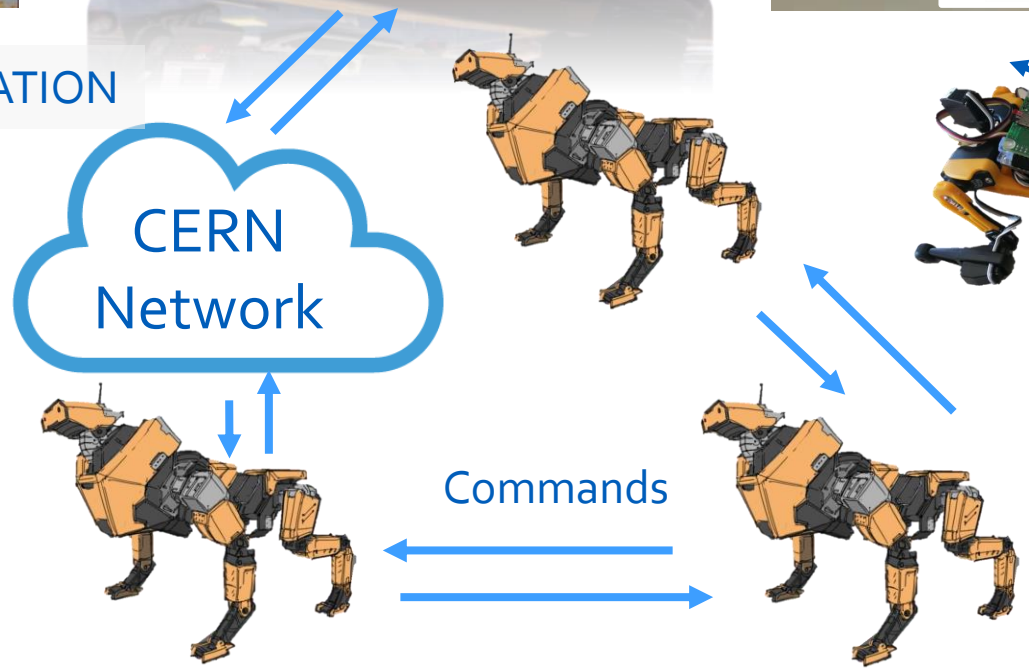
CERN Visit at the ANYbotics Zurich Headquarters

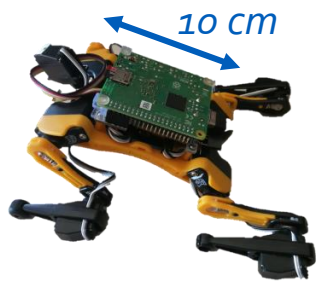
MINI QUADRUPED ROBOTS FOR INSPECTION IN CONFINED SPACE





COMMUNICATION



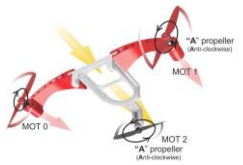


The main application: Inspection of Confined Spaces

3 items bought in January 2021 assembled and partially programmed at CERN

Network Bridge Configuration: Commands travel the various robots to reach the last one that executes the commands. Implemented at CERN

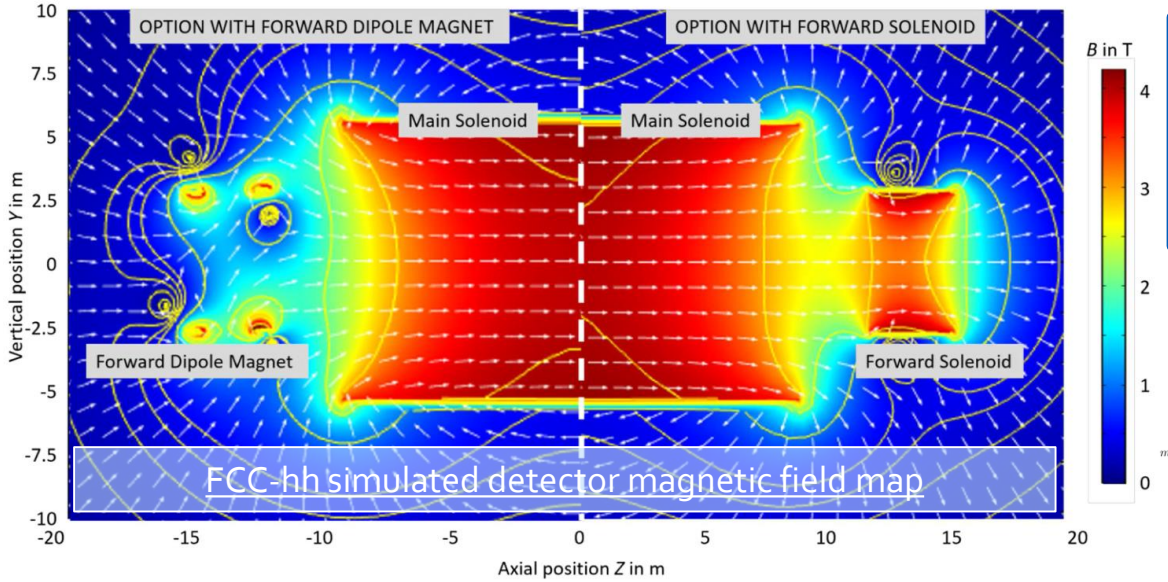
BLIMP SYSTEM FOR ENVIRONMENT MAPPING



Two commercial Blimps available at CERN.

Dynamics and control of the Blimps under investigation In Collaboration with the University of Rome la Sapienza

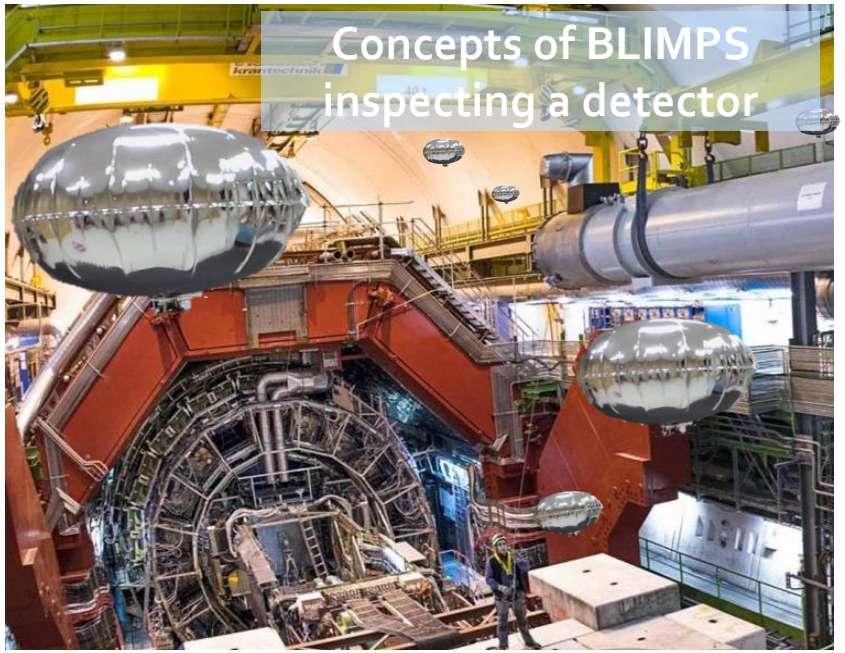
SAPIENZA UNIVERSITÀ DI ROMA



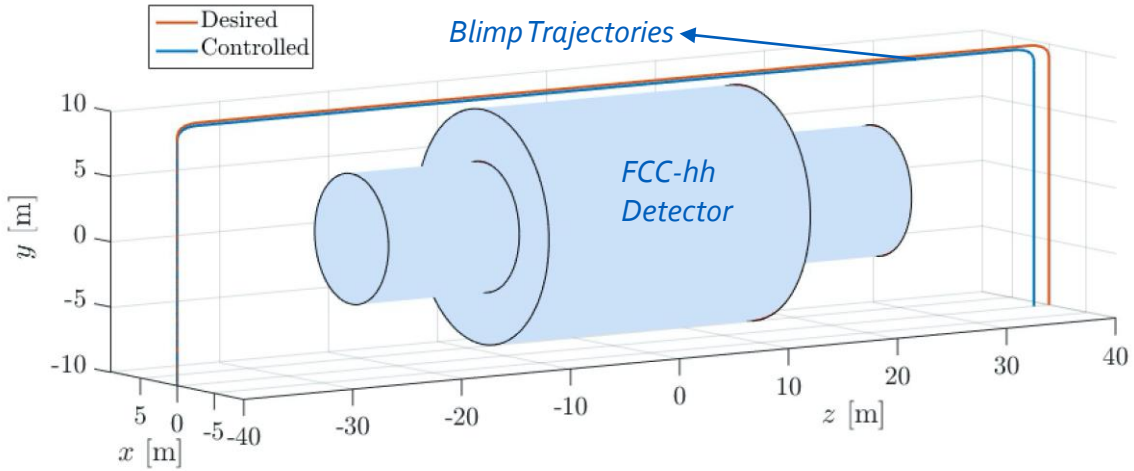
The main application: Environmental Mapping

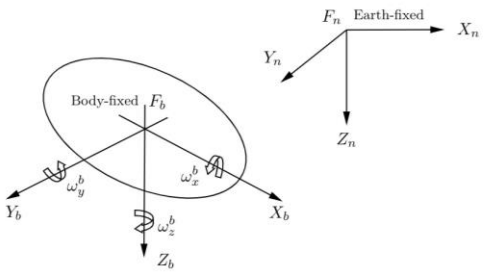
Blimps dynamical model building

$$m'_x\dot{v}^b_x + m\dot{\omega}^b_y z_G - \omega^b_z(m'_y v^b_y - m\omega^b_x z_G) + m'_z\omega^b_y v^b_z - v^b_x(D_{v_x} + D_{v|\dot{x}|}|v^b_x|) + (f_G - f_B)\sin\theta = f_{px}$$
$$m'_y\dot{v}^b_y - m\dot{\omega}^b_x z_G + \omega^b_z(m'_x v^b_x + m\omega^b_y z_G) - m'_z\omega^b_x v^b_z - v^b_y(D_{v_y} + D_{v|\dot{y}|}|v^b_y|) - (f_G - f_B)\cos\theta\sin\phi = f_{py}$$
$$m'_z\dot{v}^b_z + \omega^b_x(m'_y v^b_y - m\omega^b_x z_G) - \omega^b_y(m'_x v^b_x + m\omega^b_y z_G) - v^b_z(D_{v_z} + D_{v|\dot{z}|}|v^b_z|) - (f_G - f_B)\cos\theta\cos\phi = f_{pz}$$
$$I'_x\dot{\omega}^b_x - m\dot{v}^b_y z_G + I'_z\omega^b_y\omega^b_z - \omega^b_z(m'_y v^b_y - m\omega^b_x z_G) - \omega^b_z(I'_y\omega^b_y + mv^b_x z_G) + m'_z v^b_y v^b_z$$
$$-\omega^b_x(D_{\omega_x} + D_{\omega|\dot{x}|}|\omega^b_x|) + z_G f_G\cos\theta\sin\phi = \tau_{px}$$
$$I'_y\dot{\omega}^b_y + m\dot{v}^b_x z_G - I'_z\omega^b_x\omega^b_z + v^b_z(m'_x v^b_x + m\omega^b_y z_G) + \omega^b_z(I'_x\omega^b_x - mv^b_y z_G) - m'_z v^b_x v^b_z$$
$$-\omega^b_y(D_{\omega_y} + D_{\omega|\dot{y}|}|\omega^b_y|) + z_G f_G\sin\theta = \tau_{py}$$
$$I'_z\dot{\omega}^b_z + v^b_x(m'_y v^b_y - m\omega^b_x z_G) - v^b_y(m'_x v^b_x + m\omega^b_y z_G) + \omega^b_x(I'_y\omega^b_y + mv^b_x z_G) - \omega^b_y(I'_x\omega^b_x - mv^b_y z_G)$$
$$-\omega^b_z(D_{\omega_z} + D_{\omega|\dot{z}|}|\omega^b_z|) = \tau_{pz}$$



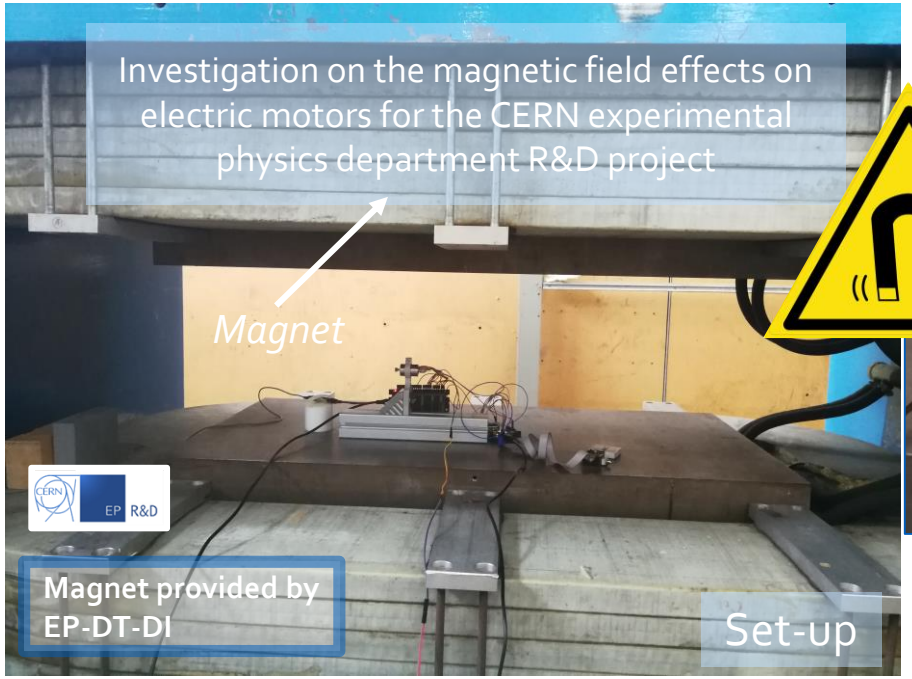
Example of simulated desired and controlled trajectory of a blimp considering the FCC-hh magnetic field



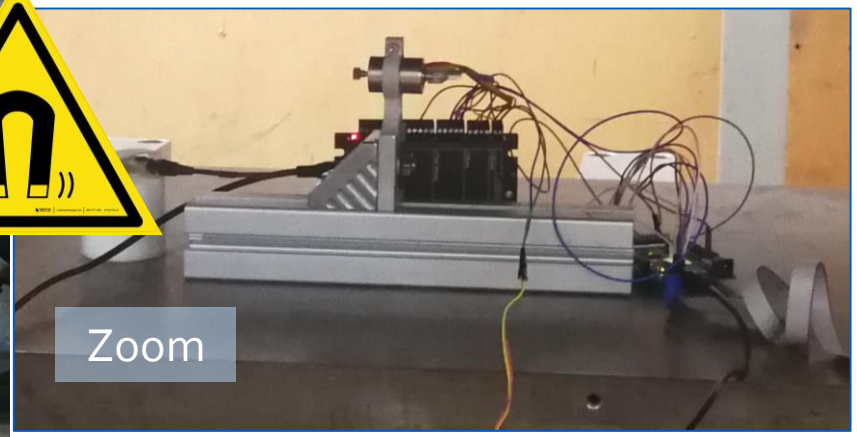


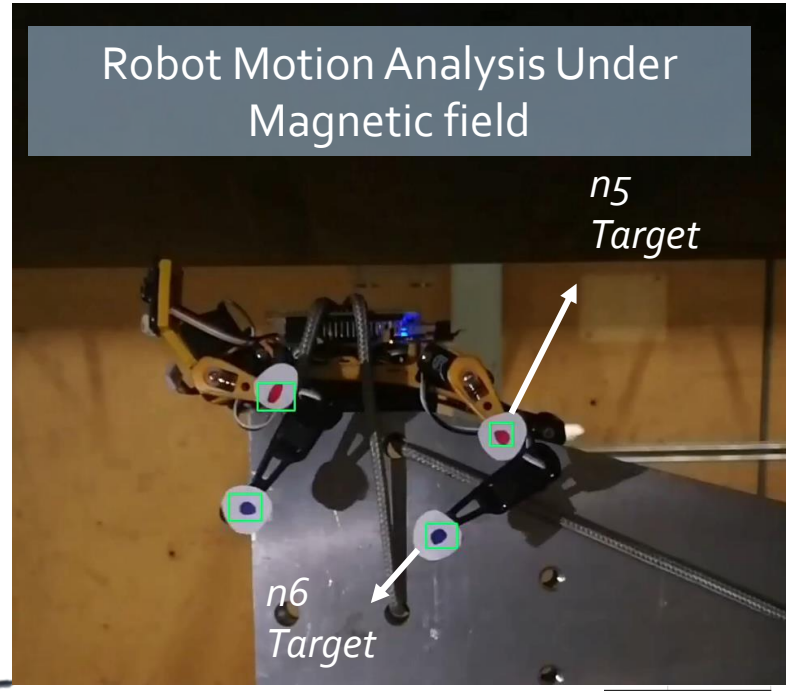
Blimp Control Analysis performed with arbitrary blimp dynamic parameters, measurements of the actual parameters on going

A POSSIBLE CHALLENGE: THE MAGNETIC FIELD ENVIRONMENT FOR MOTORS



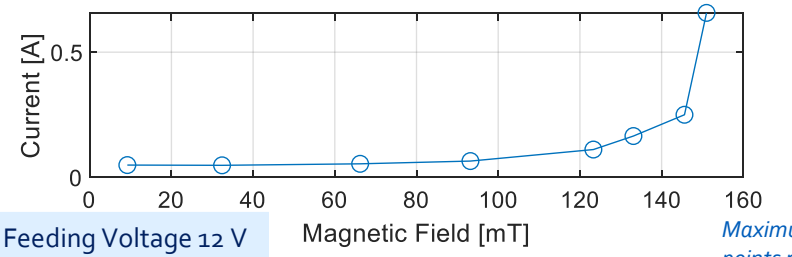
Electric motors works up to a certain value of the external magnetic field



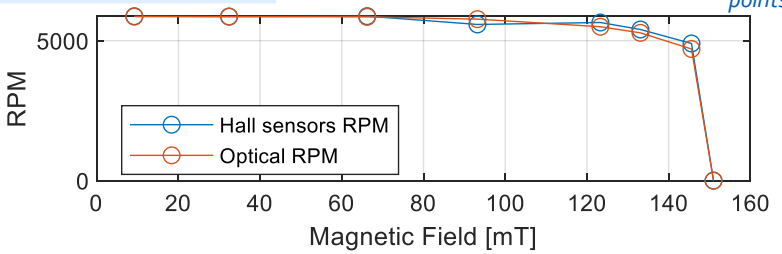


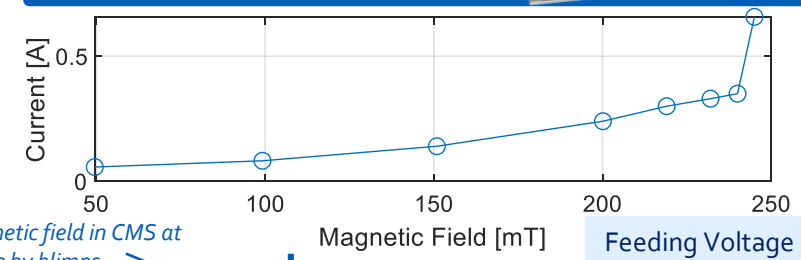
Testing Electric Motors in Magnetic Fields

EC MAX 283840



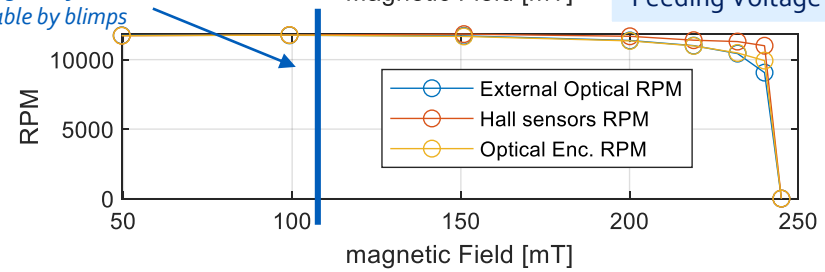
Feeding Voltage 12 V

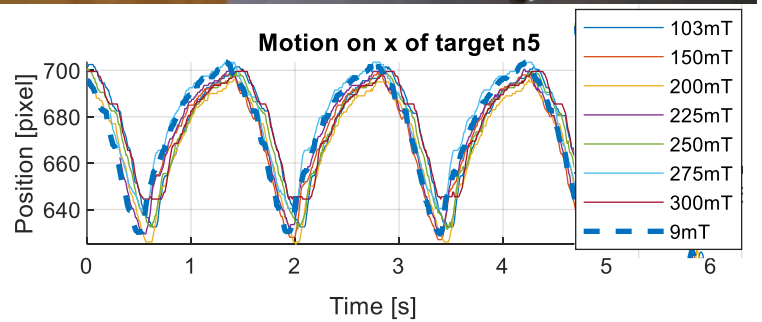




Maximum magnetic field in CMS at points reachable by blimps

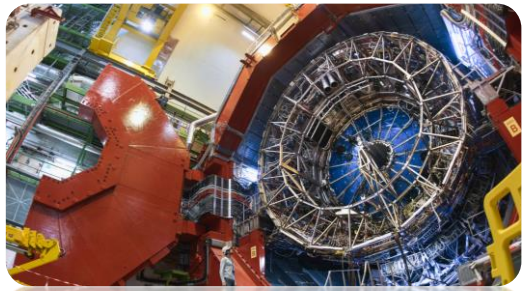
Feeding Voltage 24 V





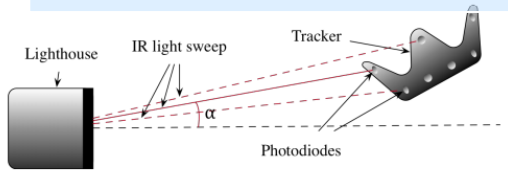
There is no major variation on the targets' motion for magnetic field values between 9 and 300 mT
1 pixel = 0.33 mm

INTERFACES



Implement techniques for designing optimal robotic/automation interface components on components to be built as the ALICE3Patch Panel

ROBOTIC SYSTEMS



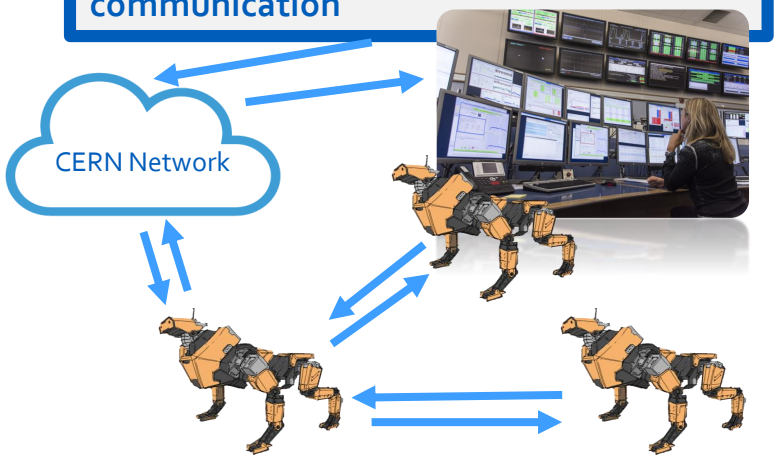
Implement a motion capture positioning system

Implement an automated system for tracker extraction (Concrete example ALICE3tracker)

ROBOTIC SYSTEMS

Tests in the CERN Environment

Improve motion and view capabilities test of the network bridge communication



Blimp payload design

THANK YOU FOR YOUR ATTENTION