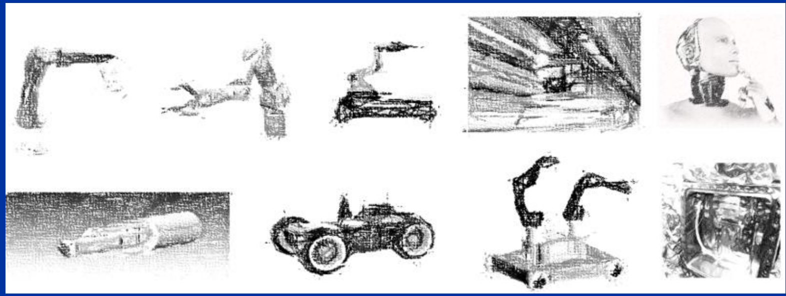


Remote Handling with Robots at CERN

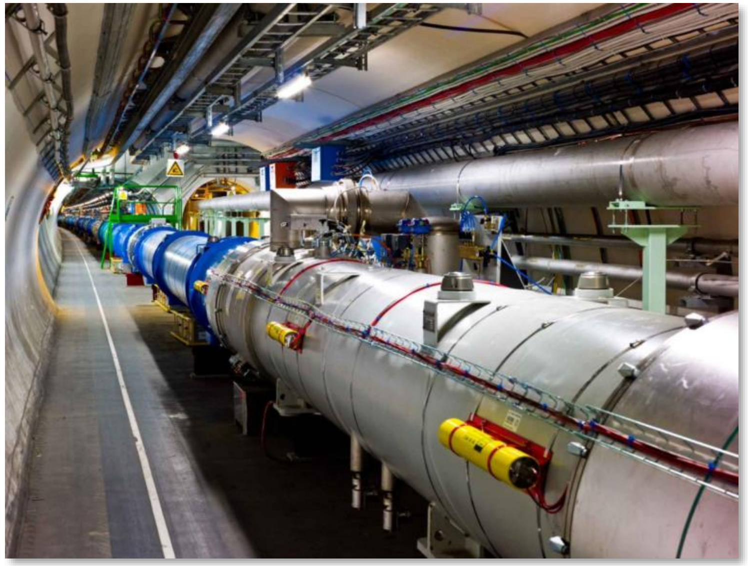
Eloise Matheson

CERN, BE-CEM group

LEAPS WG2 Meeting

Main needs for robotics at CERN

- Inspection, operation and maintenance of radioactive particle accelerators devices for **safety, maintainability, reliability and availability increase**
  - ✓ **Experimental areas and objects not built to be remote handled/inspected**
    - ✓ Any intervention may lead to “**surprises**”
    - ✓ Several risks, including **contamination**



The LHC tunnel

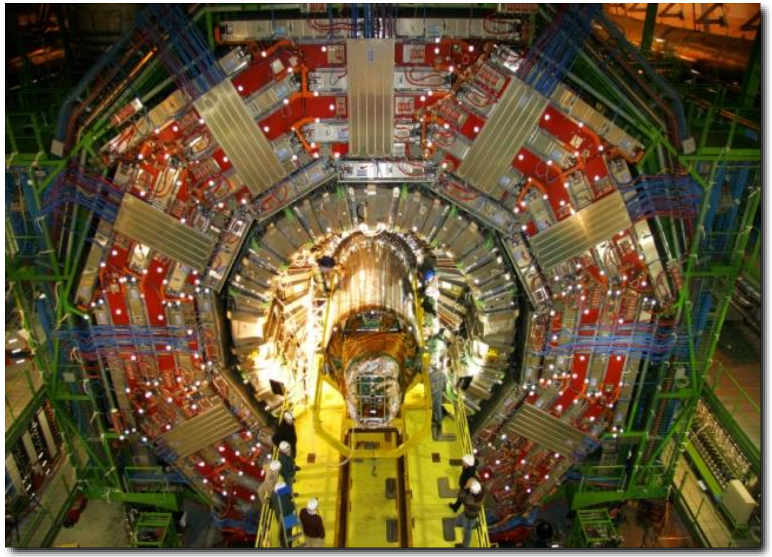
North Area experimental zone

Radioactive sample handled by a robot

Main difficulties for robotics at CERN

- **Harsh and semi-structured environments, accessibility**
- **Radiation, magnetic disturbances**, delicate equipment not designed for robots, big distances, communication, time for the intervention, highly skilled people often required (non robotic operators), etc.



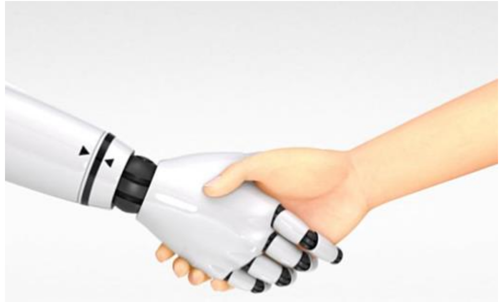



Availability of Particle Accelerators

Reliability	Maintainability	Availability
If Constant	Increase ↑	Increase ↑
If Constant	Decrease ↓	Decrease ↓
Increase ↑	If Constant	Increase ↑
Decrease ↓	If Constant	Decrease ↓

Reliable robots must be developed, and recovery scenarios must be foreseen

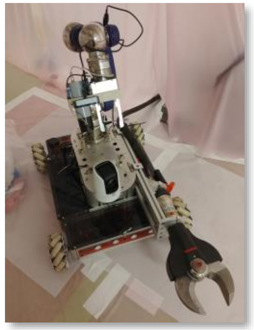
- @ constant machine reliability, maintainability drives availability
- Improve maintainability increasing efficiency of human interventions
  - ✓ using robots in collaborations with humans



The Robotic Service at CERN: Our Robots

Telemax robot

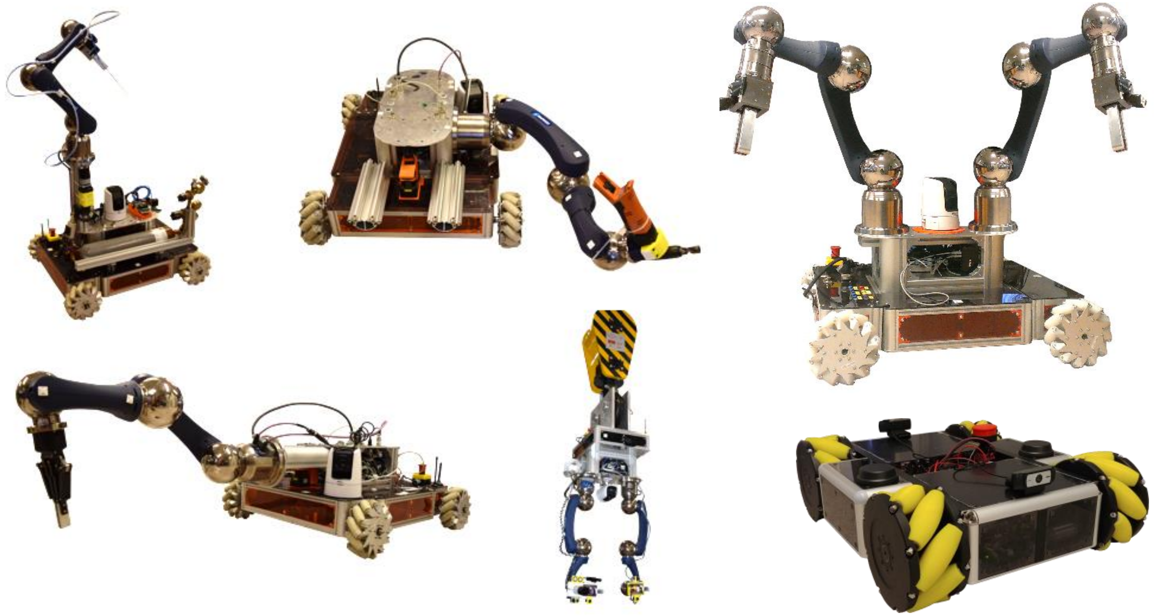
Train Inspection Monorail (CERN made)



More than 20 robots (custom made and/or industrial with custom controls) are in operation. Mechatronics conceptions, designs, proof of concepts, prototyping, series productions, operations, maintenance, tools and procedures

Teodor robot

EXTRM robot (CERN controls)



CERNBot in different configurations (CERN made)

High payload manipulator

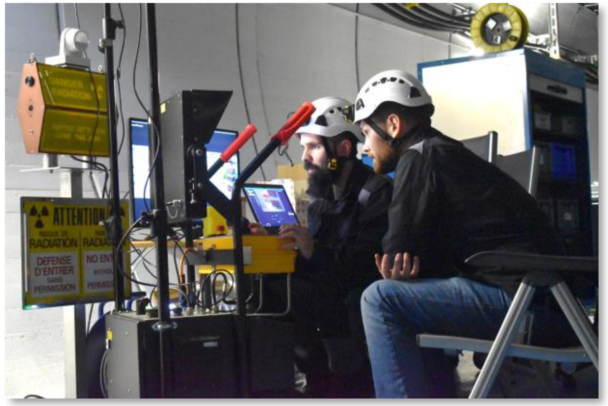
Drone for tele-operation support

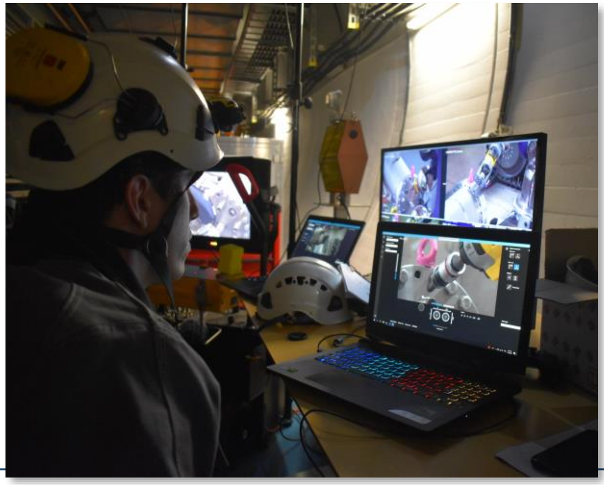
Quadrupeds for "difficult" zones

The Robotic Service at CERN

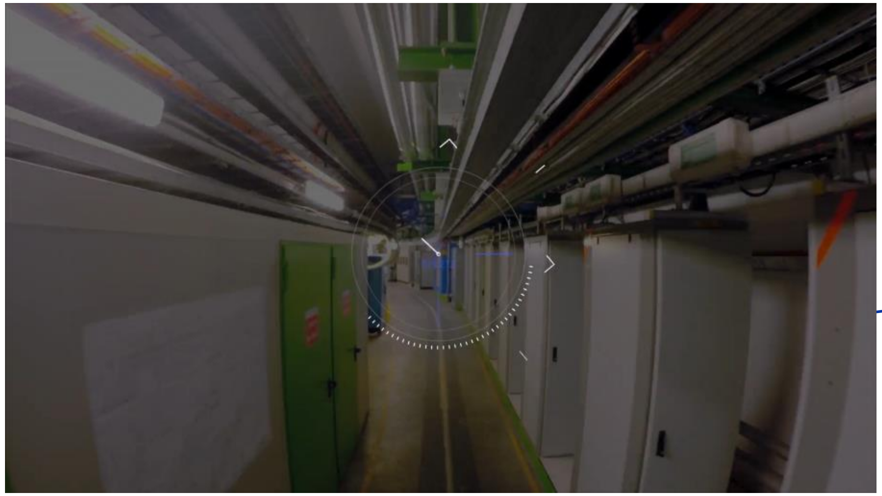
Robotics technologies are mainly used for:

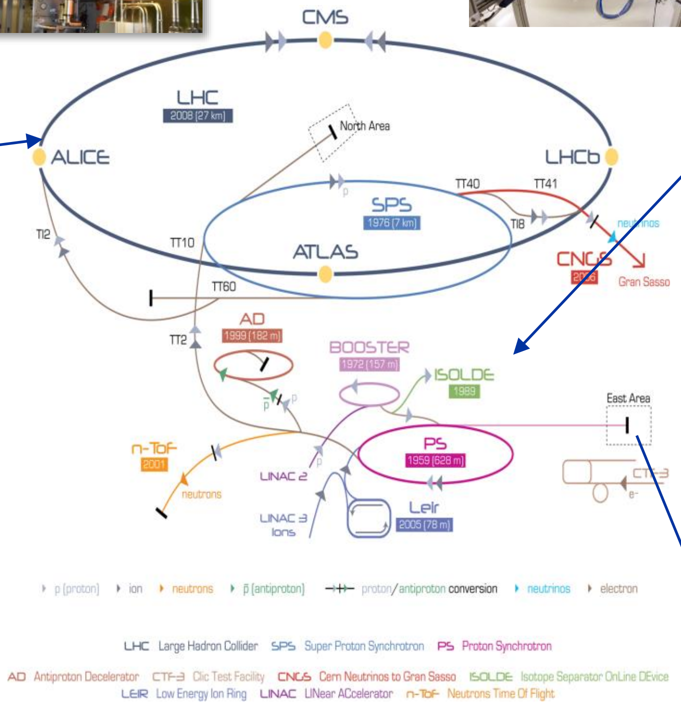
- Remote maintenance
- Human intervention procedures preparation
- Quality assurance
- Post-mortem analysis
- Reconnaissance
- Search and rescue
- And more…





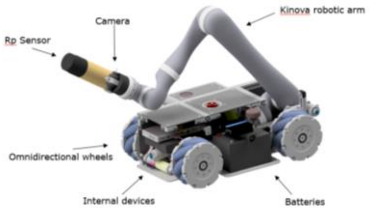
Robots integrated within accelerator facilities





4x Train Inspection Monorail (TIM)

3x ISOLDE / MEDICIS high payload industrial robots

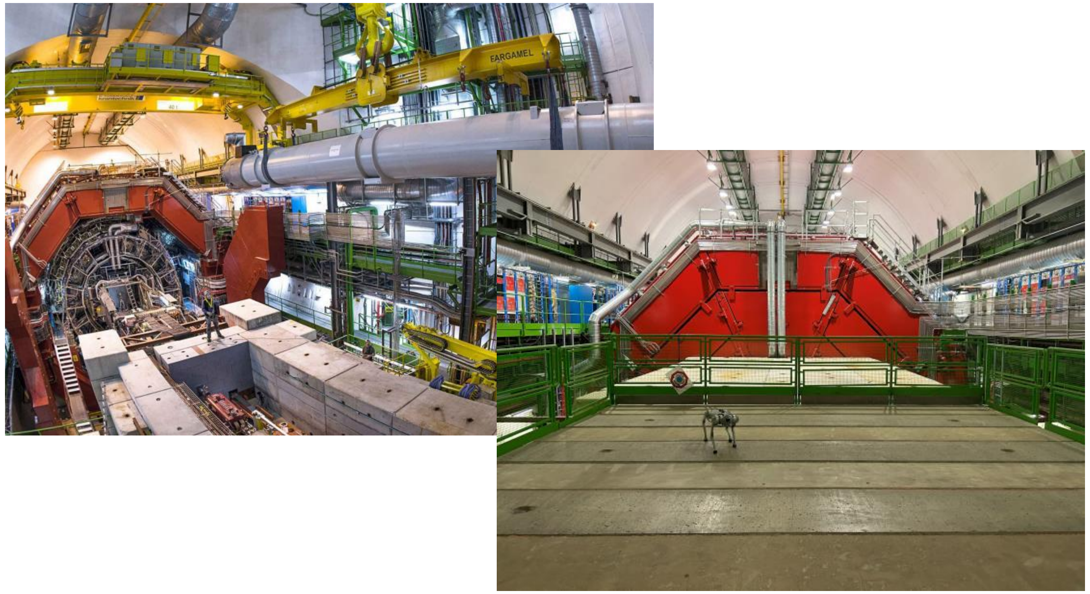


2x SPS robot

CHARM robot

Robots for use in Experimental Caverns

- ➢How to design robots for extreme environments during detector operation?
- ➢Unique challenges – unlikely to be out-of-the-box solution
- ➢Reseach durability of existing components/design new components?
- ➢Investigating best platform or combination of platforms for the environment



CHALLENGES

SOLUTIONS?

Quadruped?

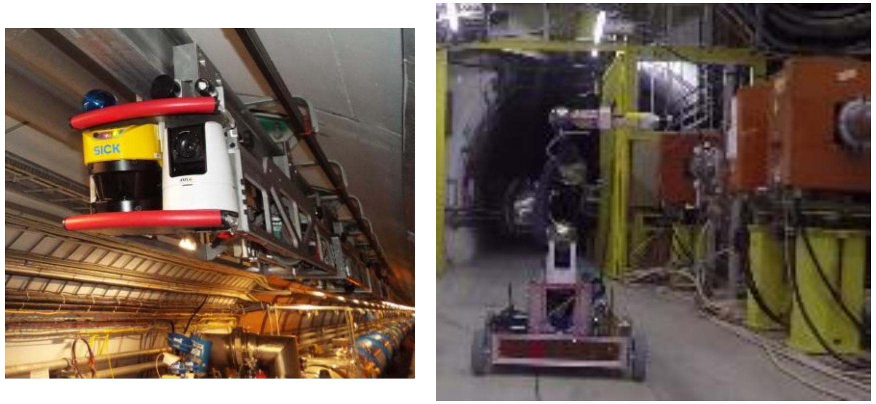
Combined Approach?

Tracked/Airborne/Other?

Novel Platform?

Robotic preventive maintenance and inspection

SPS MKP oilers refill

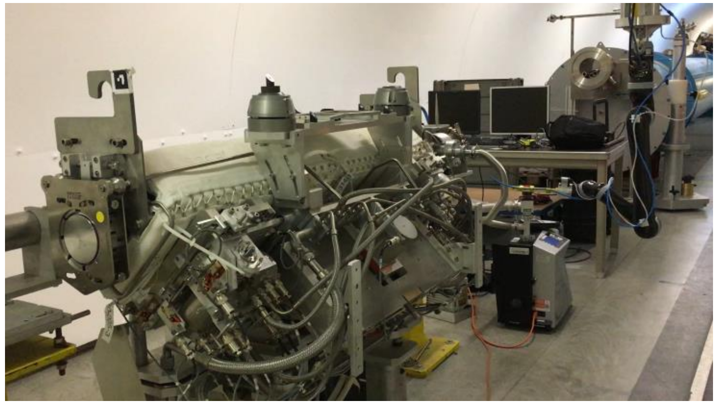


Remote radioprotection surveys

Cabling status inspection

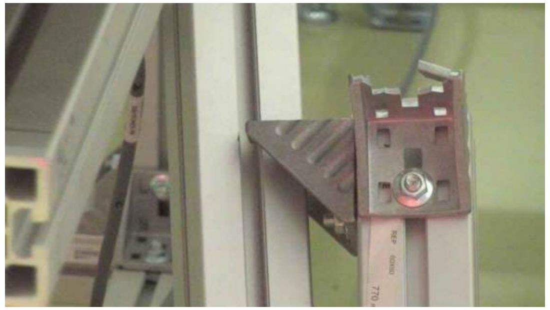
Temperature sensor installation on AD target

Tunnel structure monitoring

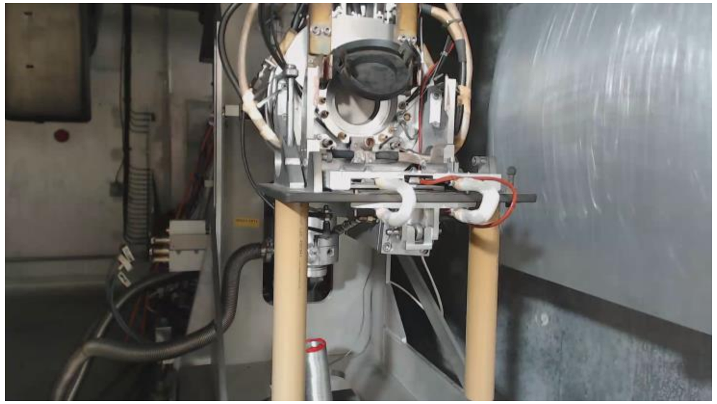


Remote Vacuum Leak detection

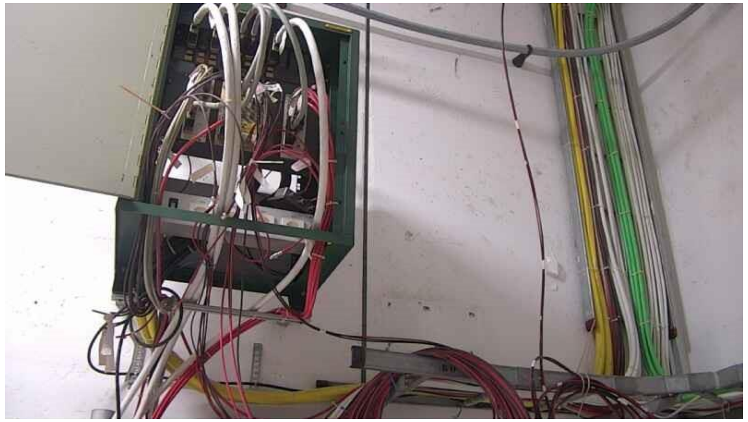
Fast reaction to equipment failures in radioactive areas



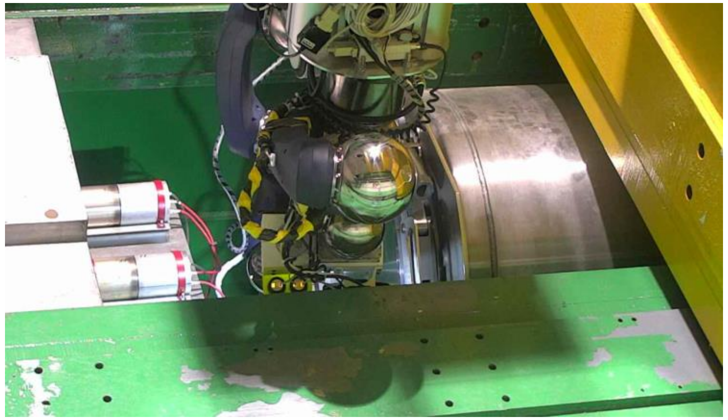

CHARM Target
In place 1 hour after the call




ISOLDE HRS Front-End
In place 2 hours after the call

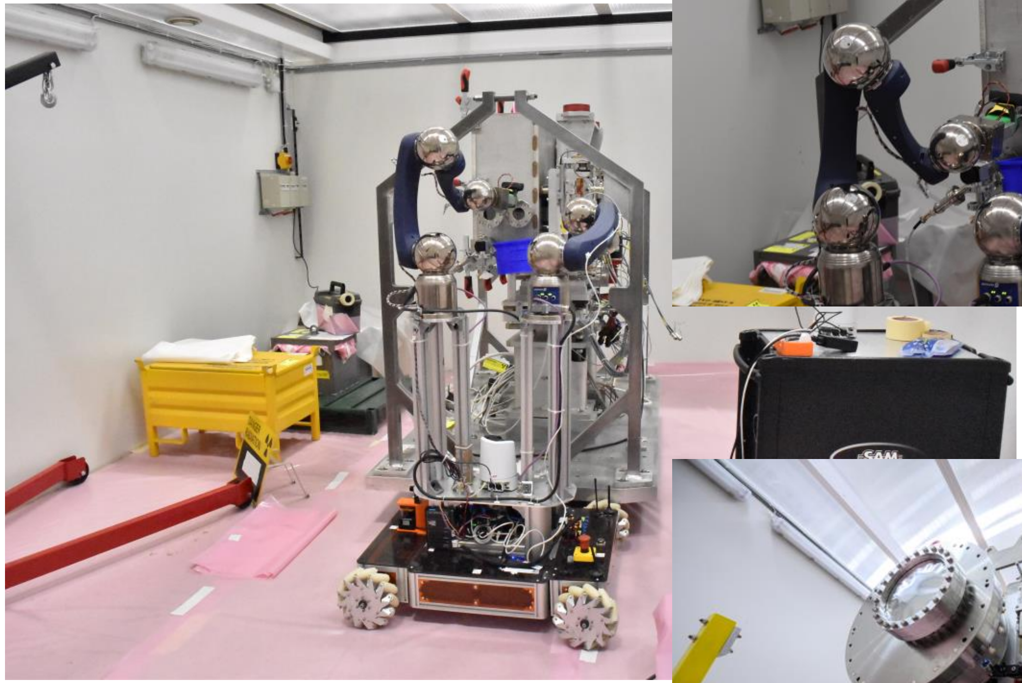


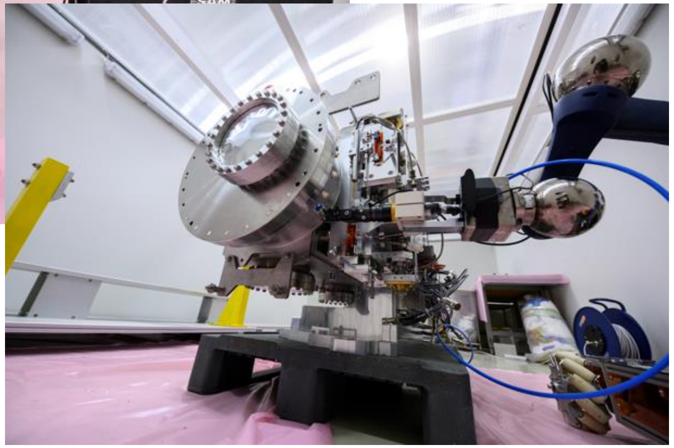
North Area BLM cables connection
In place 50 minutes after the call

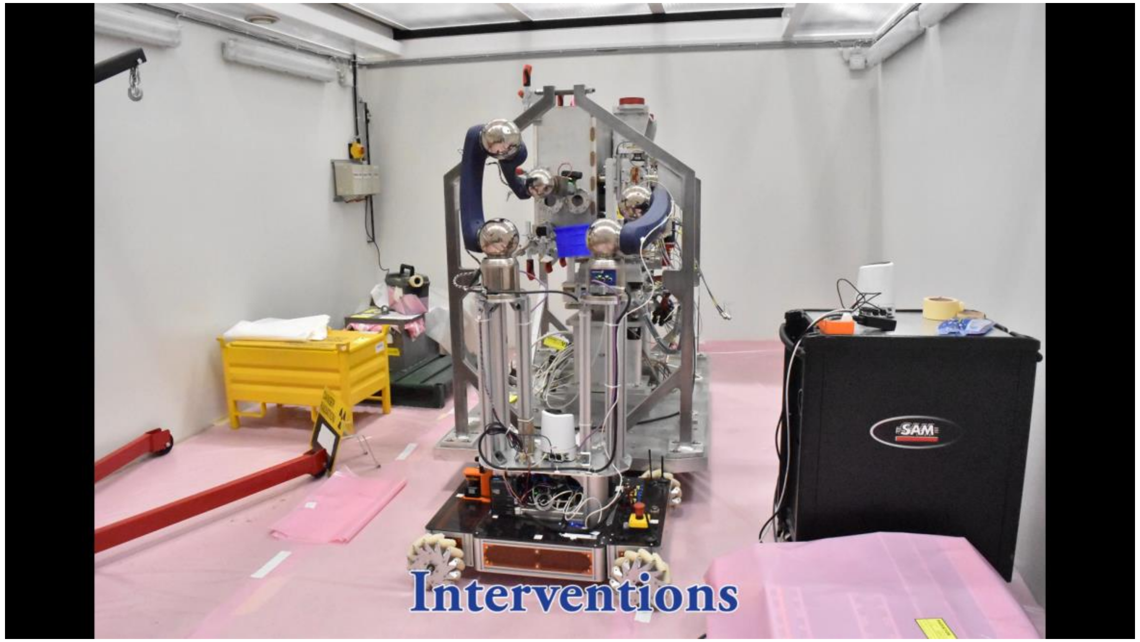


LHC TDE
New robot built in 3 days

Post-Mortem Analysis

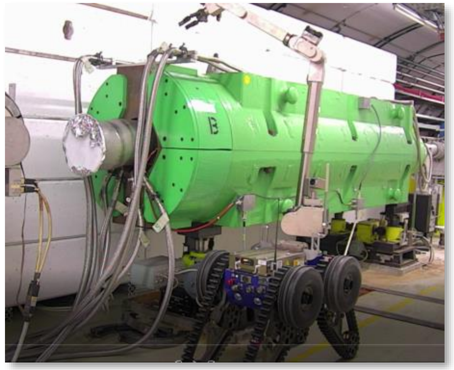


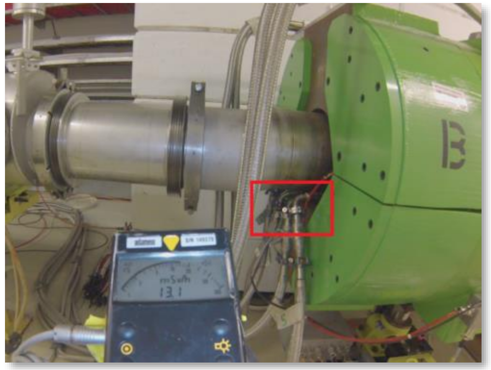


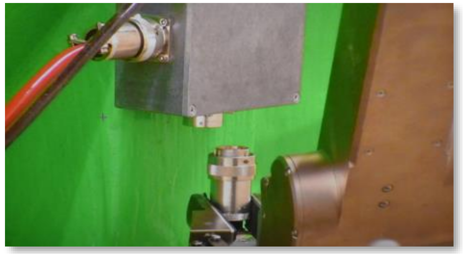


Importance of the design phase

- Designing machines that can be maintained by robots using appropriate and easily accessible interfaces will increase maintainability and decrease human exposure to hazards







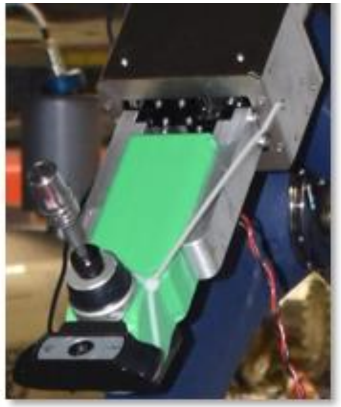
Easier remote or hands-on manipulation than chain-type connection

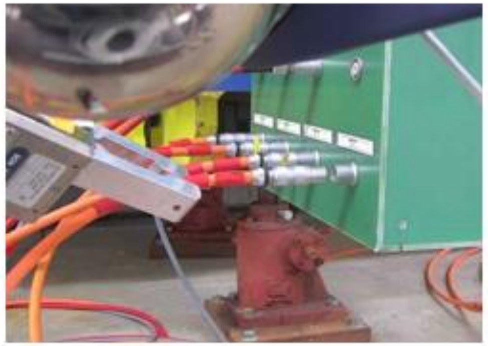
Procedures and Tools

- Several time consuming and costly tools, procedures and Mockups done for intervention on non-robotic friendly interfaces during the last years (several done also in emergency situations)
  - ✓ **Intervention procedures, recovery scenarios, tools and mock-ups are as important as the robot/device that does the remote intervention**
  - ✓ Standardization of interfaces → standardized tools and procedures, reduce costs and intervention time



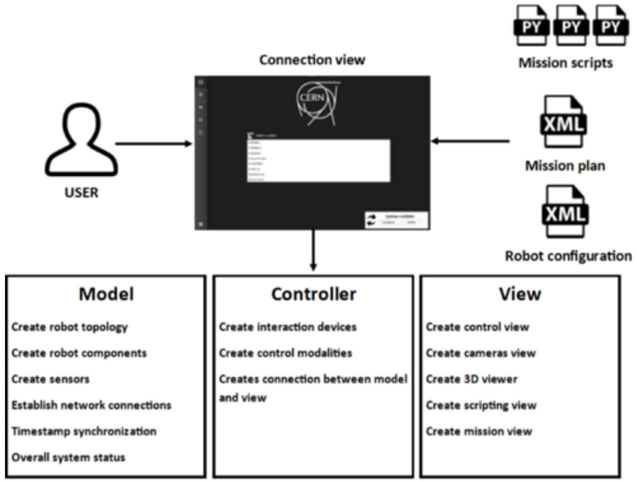


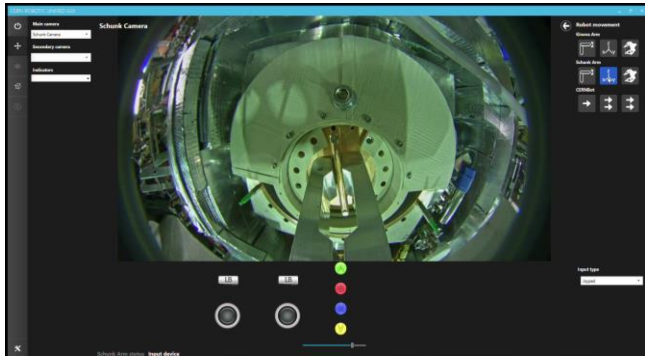



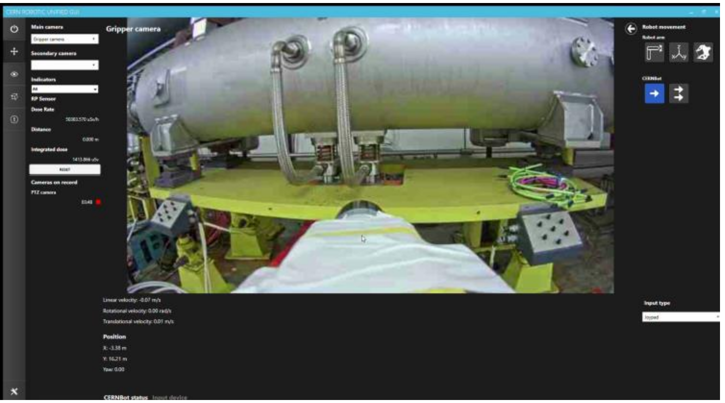


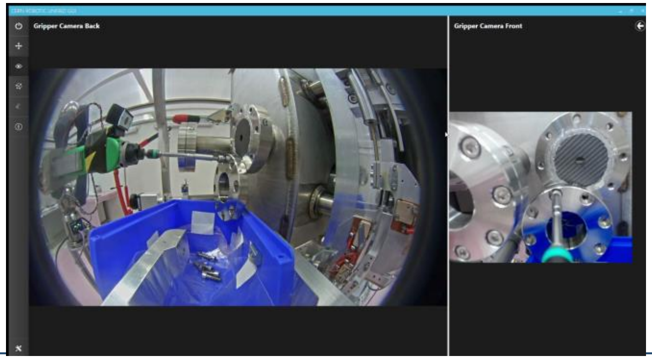
Human-Robot-Interface

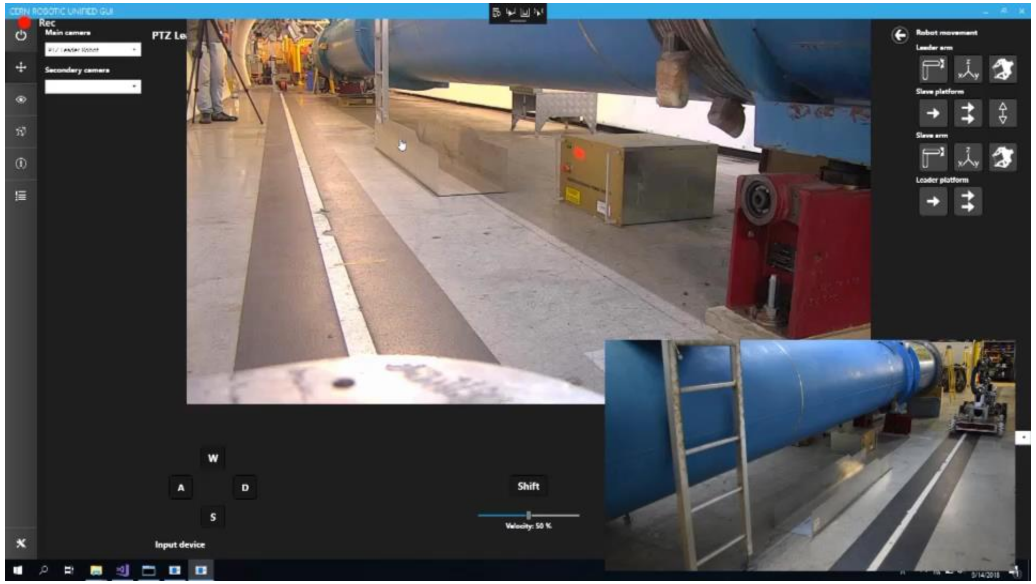
- ➢Controls all the BE-CEM robots
- ➢Includes enhanced reality modules
- ➢Different inputs device (keyboards, joystick, master arm etc.)
- ➢Operators training options
- ➢Multi screens capability
- ➢Time-delay passivation





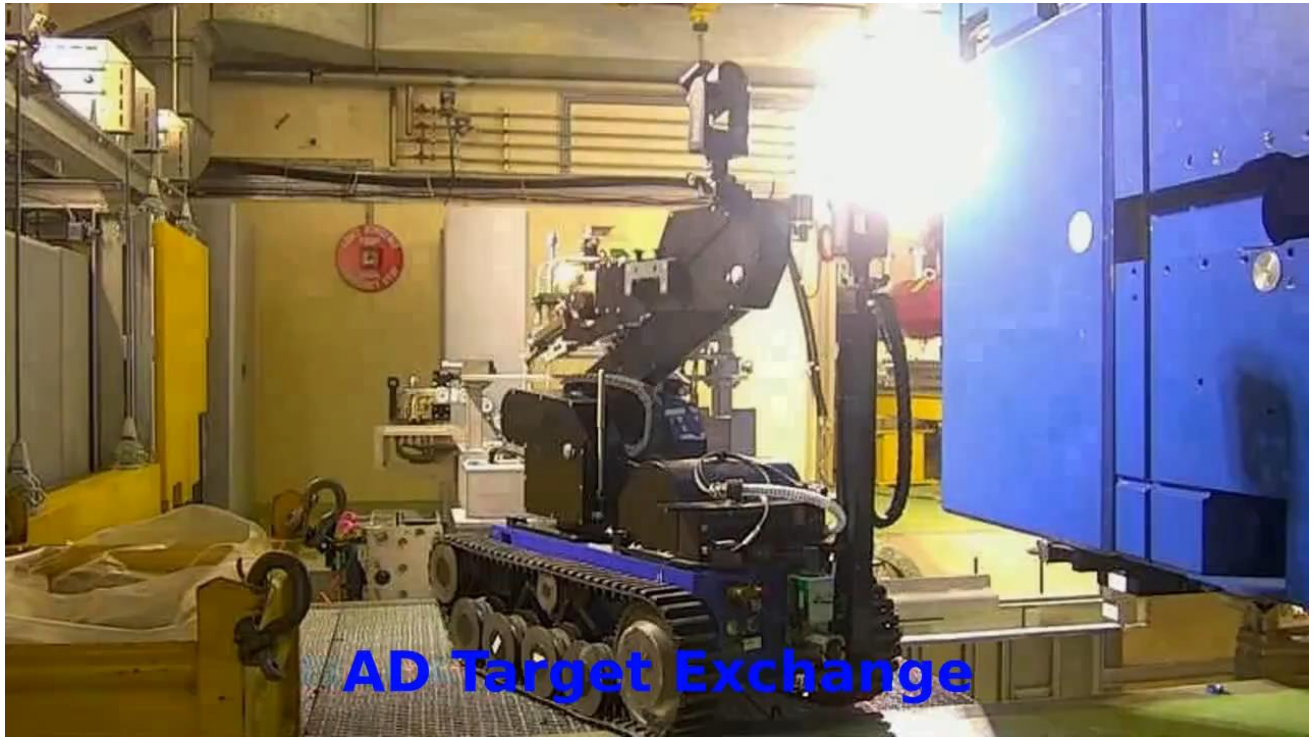


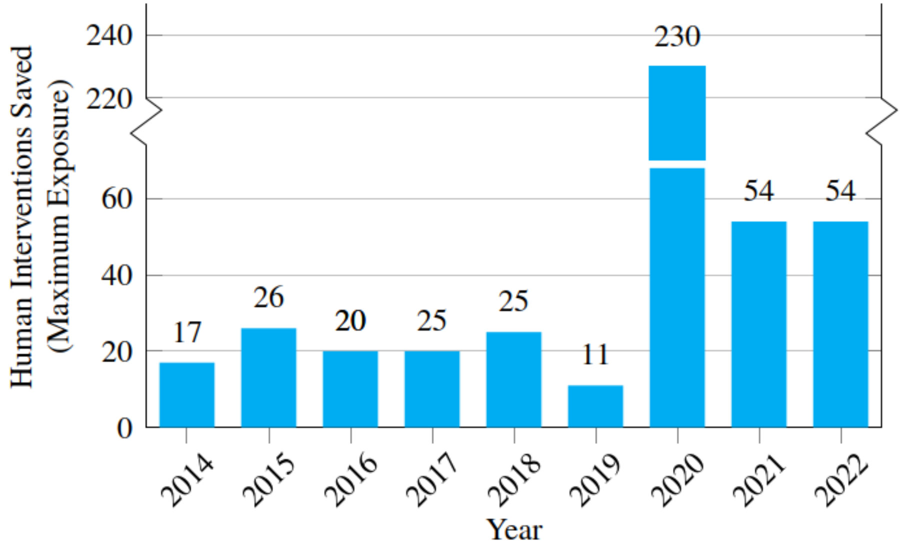




Robotic Interventions

- ➢ More than **1000 robotic operations** over the last 8 years
- ➢ More than **1500 hours of in-situ robotic operations**
- ➢ Strong machine **availability boost** thanks to planned and unplanned/emergency missions
- ✓ Continuing developing **best practices** for equipment design and robotic intervention procedures and tools including recovery scenarios

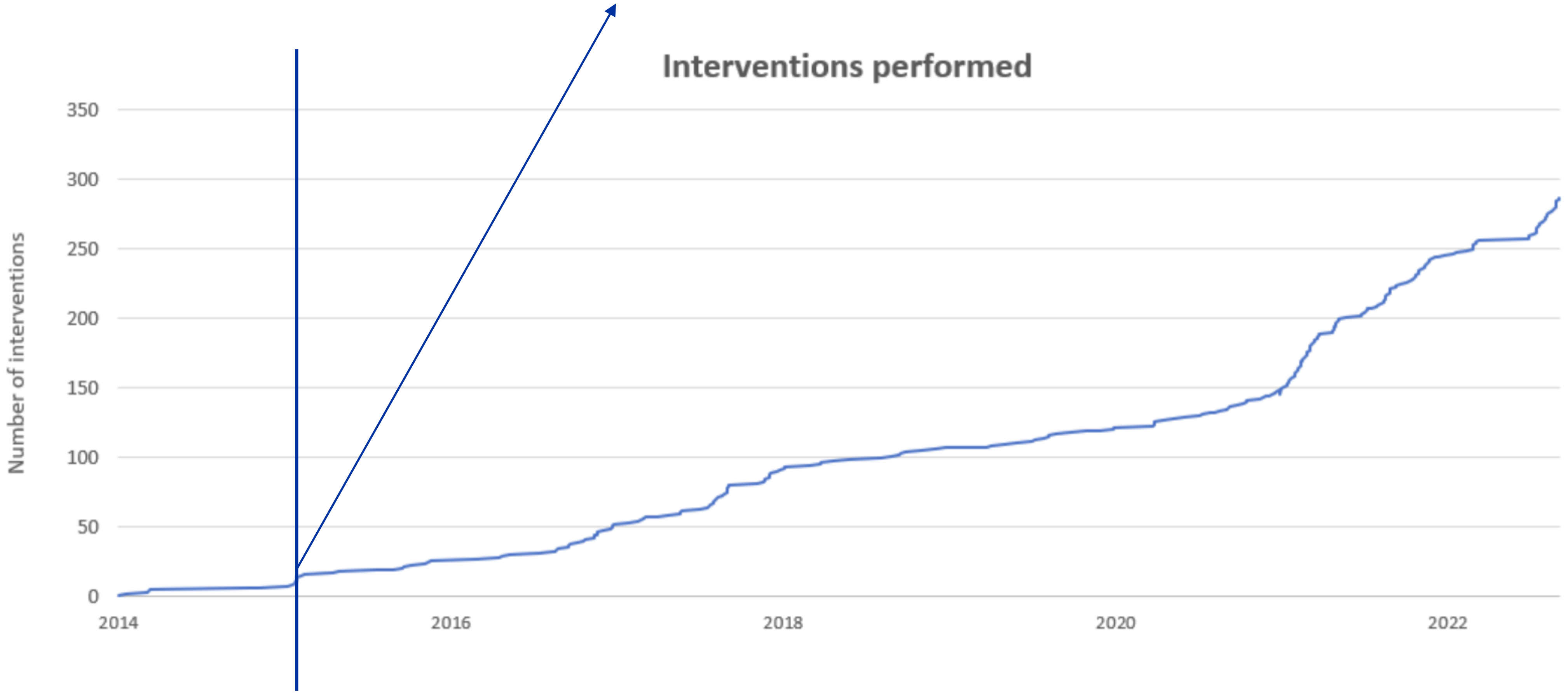




The equivalent number of human interventions saved with robotic interventions assuming maximum annual exposure

Robotic Interventions

Started to apply CERN custom made robotic solutions.
Remote maintenance capabilities and modularity strongly increased!



Conclusions

- Particle accelerators devices are normally installed for many years and tasks of dismantling radioactive objects is inherited by the future generation of physicists/technicians/engineers

- Maintenance and dismantling tasks, over a lifetime of a particle accelerator device, must be taken into account at design phase

- Robotic intelligent and robust systems can increase personnel safety and machine availability in performing such tasks

- Ready-to-use industrial solutions do not exist for user friendly remote maintenance and inspection

- We gained an important knowledge and experience in designing, producing and applying robots in harsh and hazardous environment

- External collaboration with Robotics Research Centres and Universities is crucial to take advantage of the cutting edge technology

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