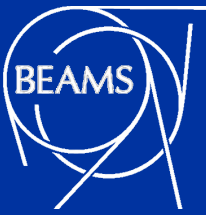




Controls
Electronics &
Mechatronics



Critical Neural Networks for Robotic and Mechatronic Applications

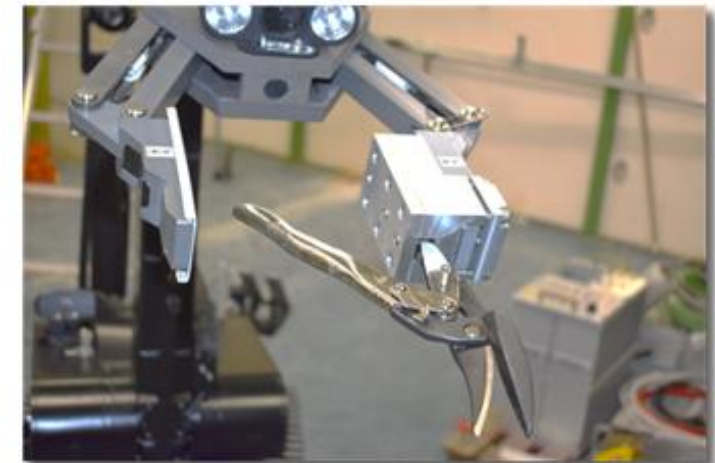
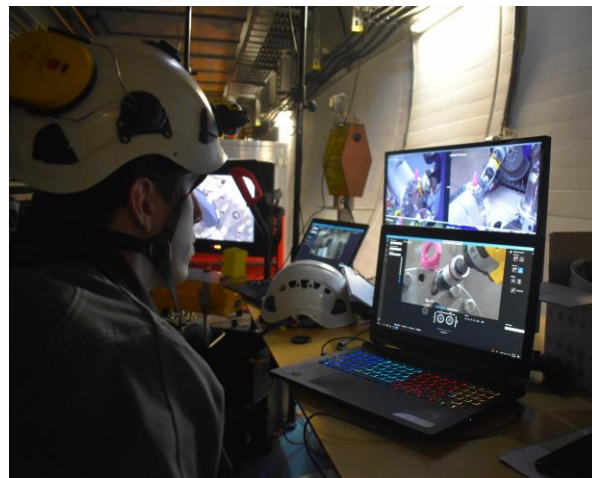
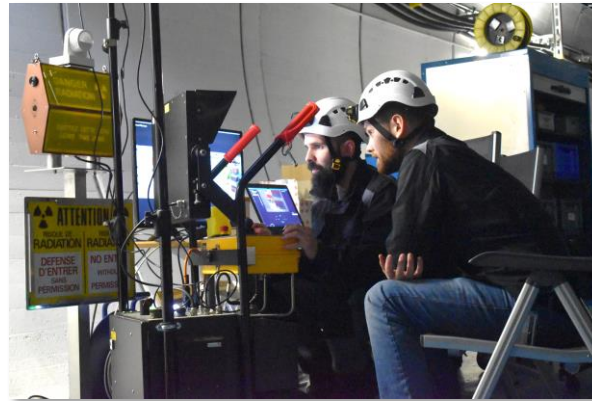
Álvaro García González

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...



The Robotic Service at CERN: Overview of robots pool



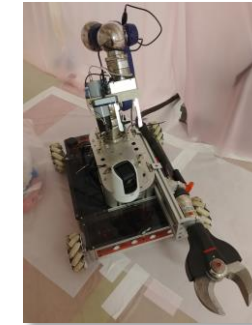
More than 20 robots (custom made and/or industrial with custom controls) are in operation. Mechatronics conceptions, designs, proof of concepts, prototyping, series productions, operations, maintenance, tools and procedures



Telex robot



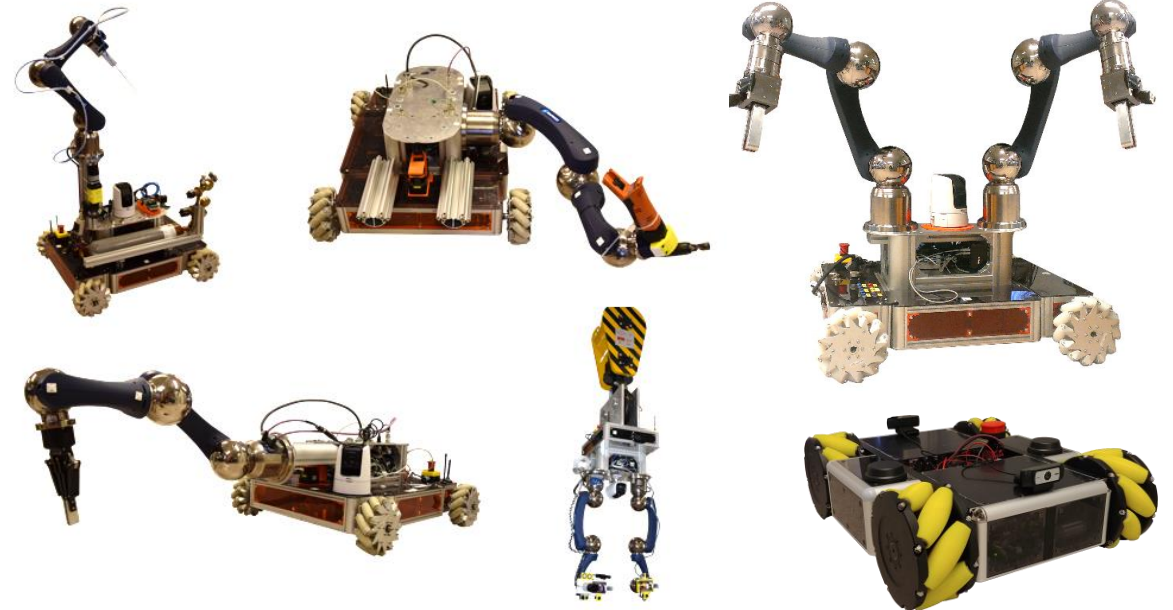
Train Inspection Monorail (CERN made)



Teodor robot



EXTRM robot (CERN controls)



CERNBot in different configurations (CERN made)



High payload manipulator

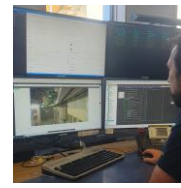


Drone for tele-operation support

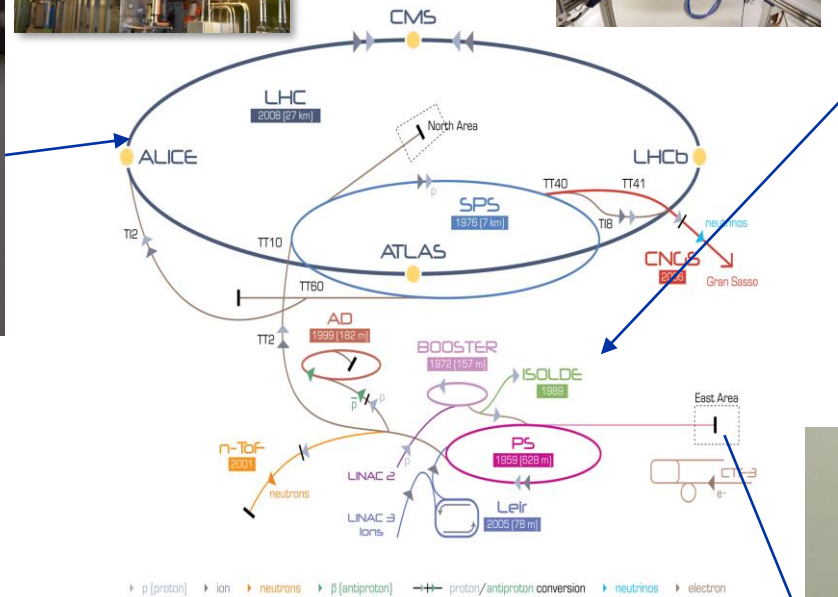


Quadrupeds for "difficult" zones

Robots integrated within accelerator facilities



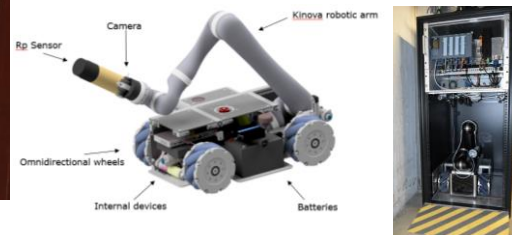
4x Train Inspection Monorail (TIM)



3x ISOLDE / MEDICIS high payload industrial robots



2x SPS robot



CHARM robot

Beam Loss Monitor Calibration



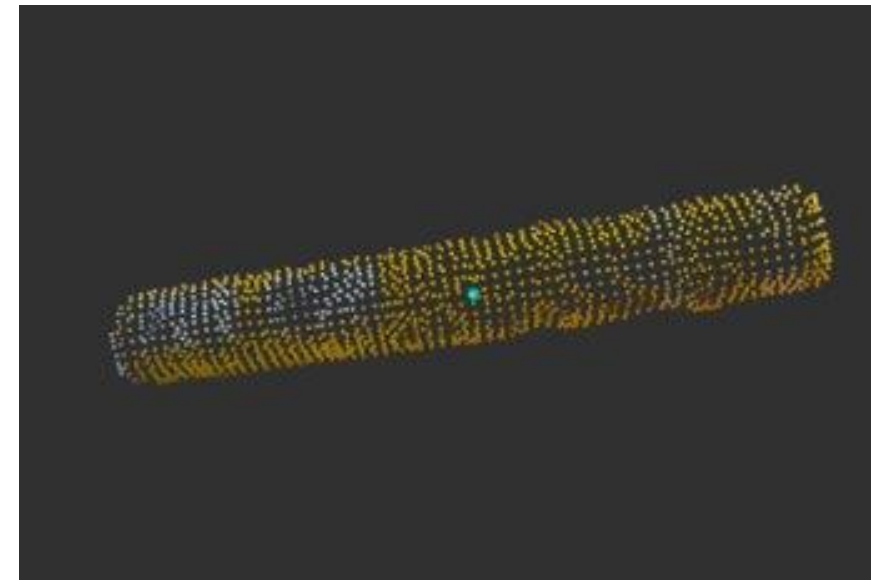
Robotic arm performing a BLM Calibration

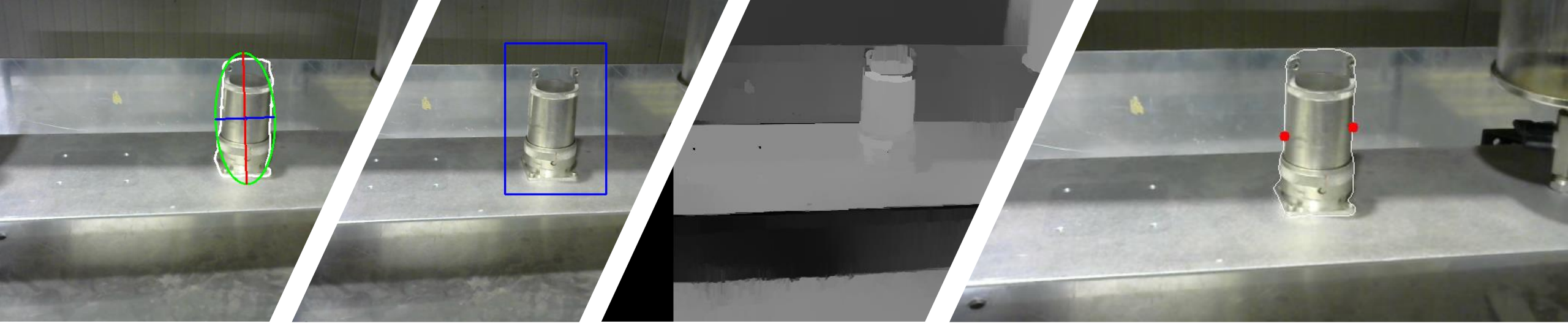


Train Inspection Monorail (CERN made)

Beam Loss Monitor Validation

- **Mask-RCNN Algorithm:** Outputs the bounding boxes and the segmentation masks of the BLMs.
- **Goal:** Estimating the pose of BLMs in the LHC accelerator using RGB-D cameras for generating safe arm trajectories





Monocular Camera-Based Robot Grasping Strategy for Metallic Objects

Recognition of metal objects on surfaces with lack of contrast

Contour-based stable grasping points calculation.

Spatial coordinates estimations based on monocular stereo vision technique.

Approaching to the object using object coordinates in robot frame.



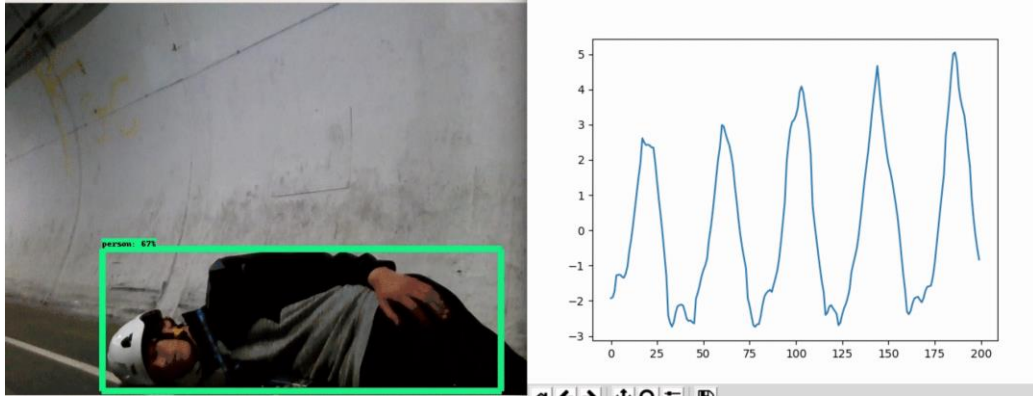
People Recognition and Vital Monitoring

Requested by HSE

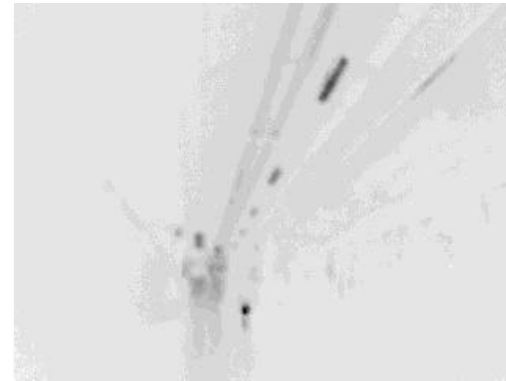
- Machine learning techniques enhance people detection and vital signals monitoring at distance
- People search and rescue is of primary interest in disaster scenarios
- People monitoring during rehabilitation



Vision system (2D Laser, radar, thermal and 2D-3D camera)



Online respiration monitoring

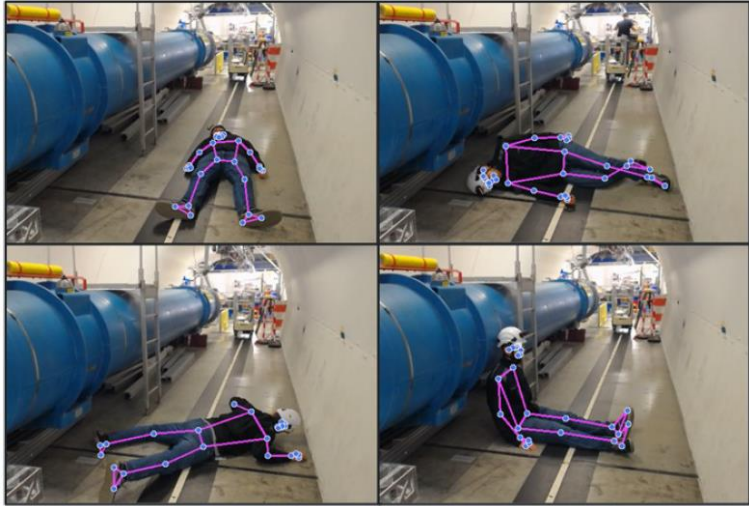
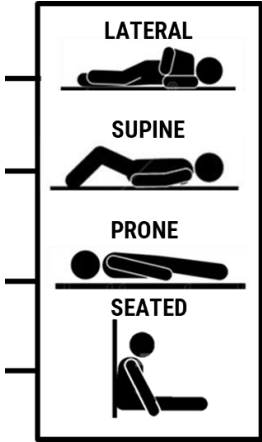
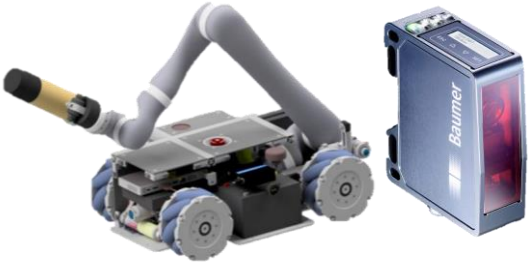
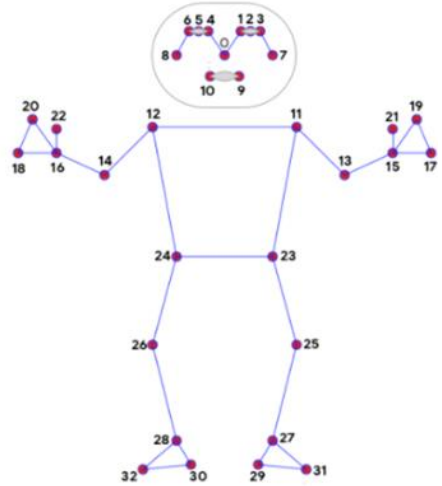
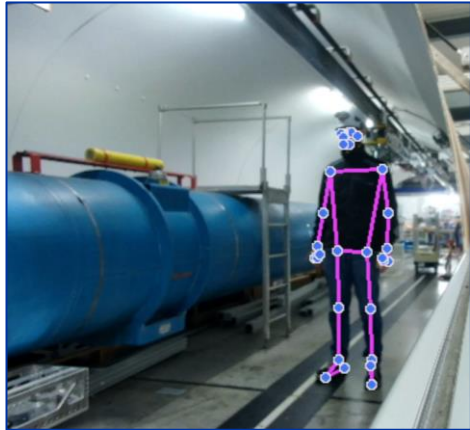


Online people recognition and tracking

Contactless Monitoring of Workers

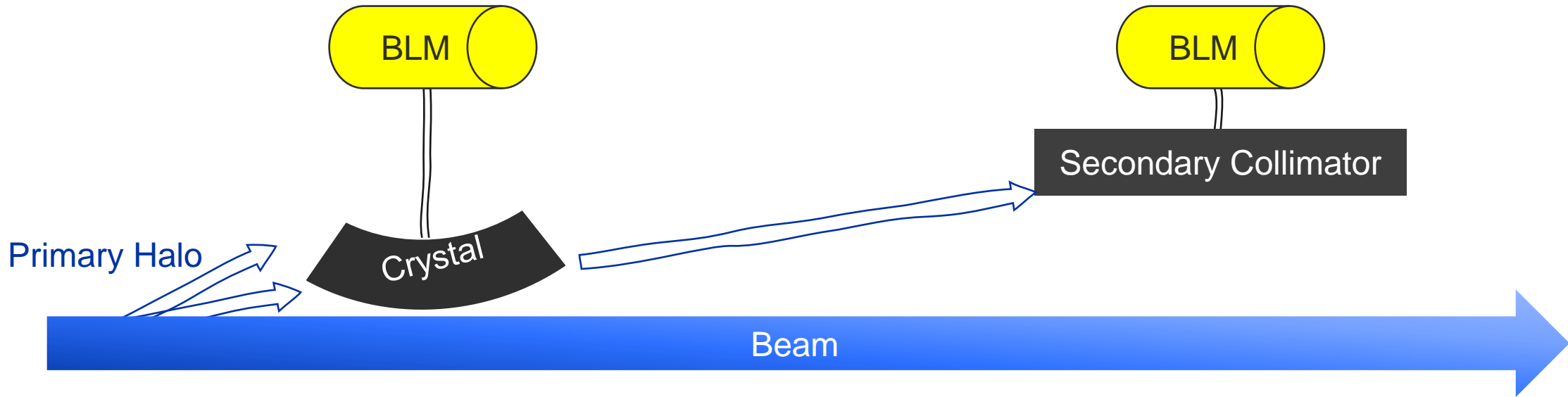


- **Detection** of different **workers postures**
- **Pointing of the laser** for respiration monitoring according to the person posture



Implementation of MEDIAPIPE framework

Crystal Alignment Automation [1]



1. 1D CNN to automatize the alignment of crystal collimators;
2. The employed CNN classifies BLM signals in real time;
3. The model achieved a precision of 93% on unseen data.

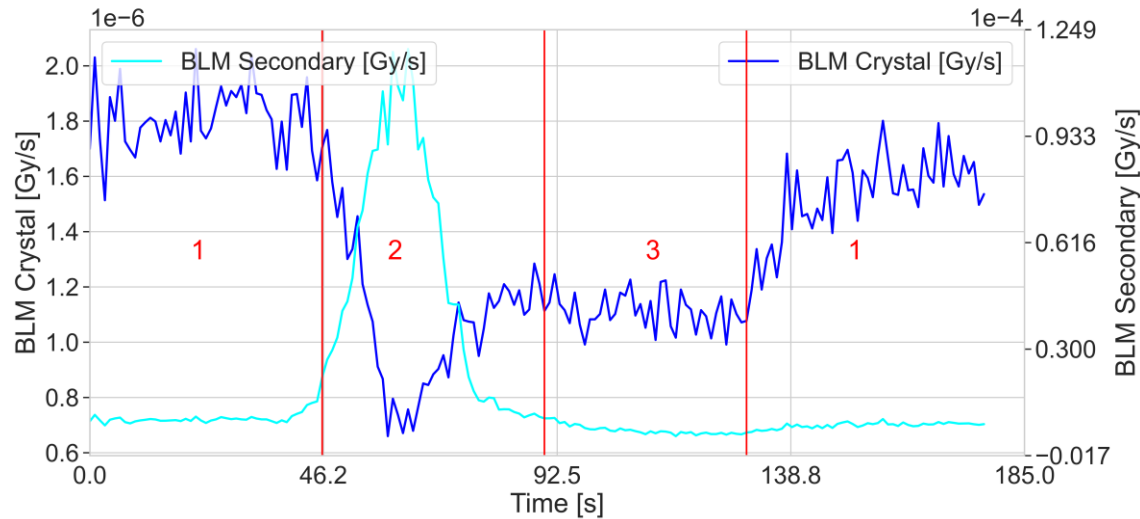


Figure:
«Channeling Well»

Real Time Crystal Monitor [2]



1. Utilize a FNN to classify the operational state of the crystal;
2. The possible states of the crystal include:
 1. Channeling;
 2. Amorphous;
 3. Volume reflection.
3. Simulated interaction of the beam with the crystal using SixTrack-FLUKA coupling;
4. The Neural Network classifies losses at key points around the accelerator.

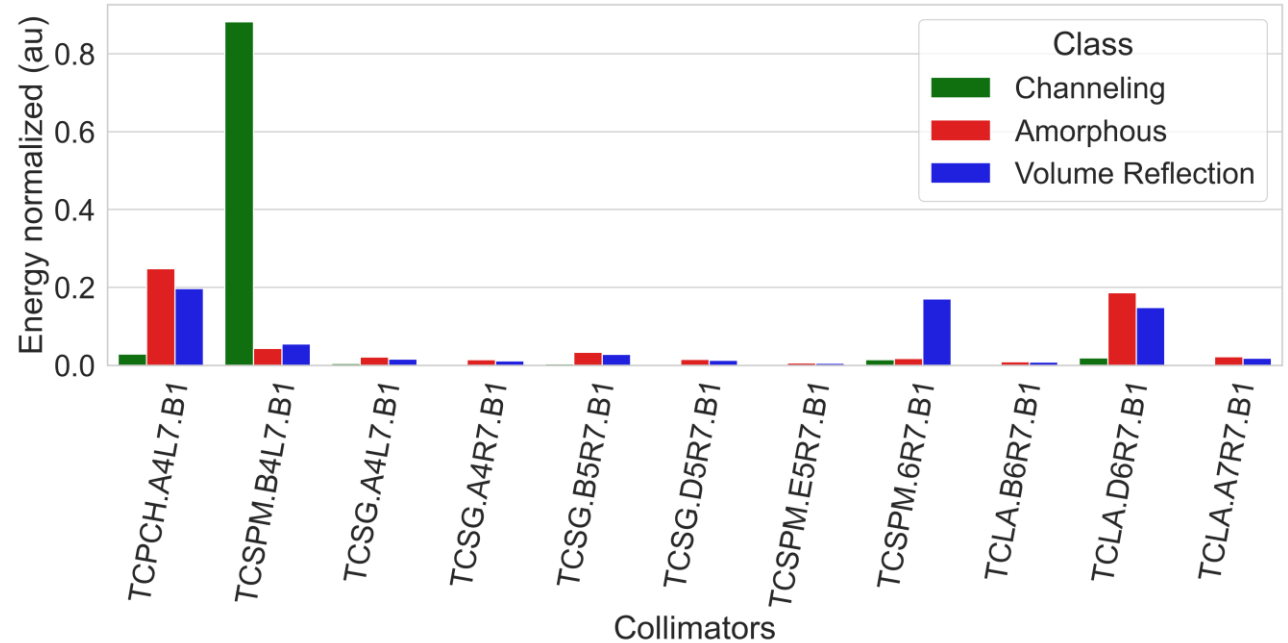


Figure: Energy distribution normalized observed on various collimator

References

- [1] Veiga Almagro, C.; Muñoz Orrego, R.A.; García González, Á.; Matheson, E.; Marín Prades, R.; Di Castro, M.; Ferre Pérez, M. (MARGOT) Monocular Camera-Based Robot Grasping Strategy for Metallic Objects. *Sensors* 2023, 23, 5344. <https://doi.org/10.3390/s23115344>
- [2] Cittadini R., Buonocore L. R., Matheson E., Di Castro, M. and Zollo L. "Robot-aided contactless monitoring of workers' cardiac activity in hazardous environment". *IEEE Access*, 10, 133427-133438, (2022)
- [3] EARLY-CAREER RESEARCHERS IN MEDICAL APPLICATIONS @ CERN – SHORT TALKS, Speaker: R. Cittadini. Link: <https://indico.cern.ch/event/1213586/overview>
- [4] CEM Technical Meeting - Crystal Collimators Alignment Optimization with Deep Learning, Speaker: G. Ricci. Link: <https://indico.cern.ch/event/1294438/>
- [5] G. Ricci et. al., "Real Time Crystal Collimation Monitoring at the CERN Large Hadron Collider (LHC)", in *Proc. IPAC'24*, p. 1747-1750. https://www.jacow.org/ipac2024/pdf/ipac-24_proceedings_volume.pdf



Many colleagues contributed to the robotic activities during the last years ... Lots of students (TRNEE, TECH, DOCT)



Robots and robotic instrumentation need a crew to use them and maintain and experts in-house to be effective



beams.cern