Calculations of the radiological environment for handling of ISOLDE targets

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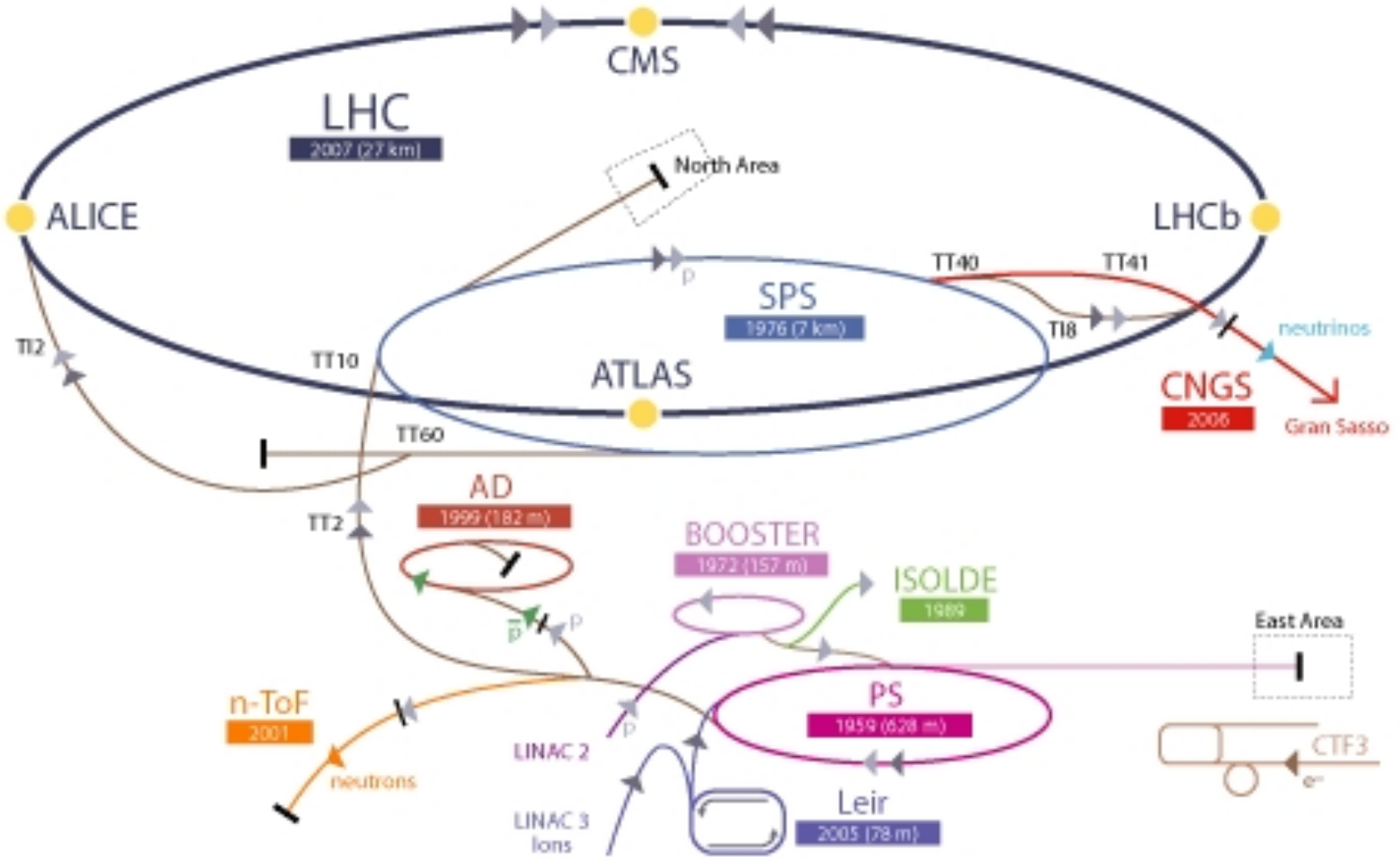
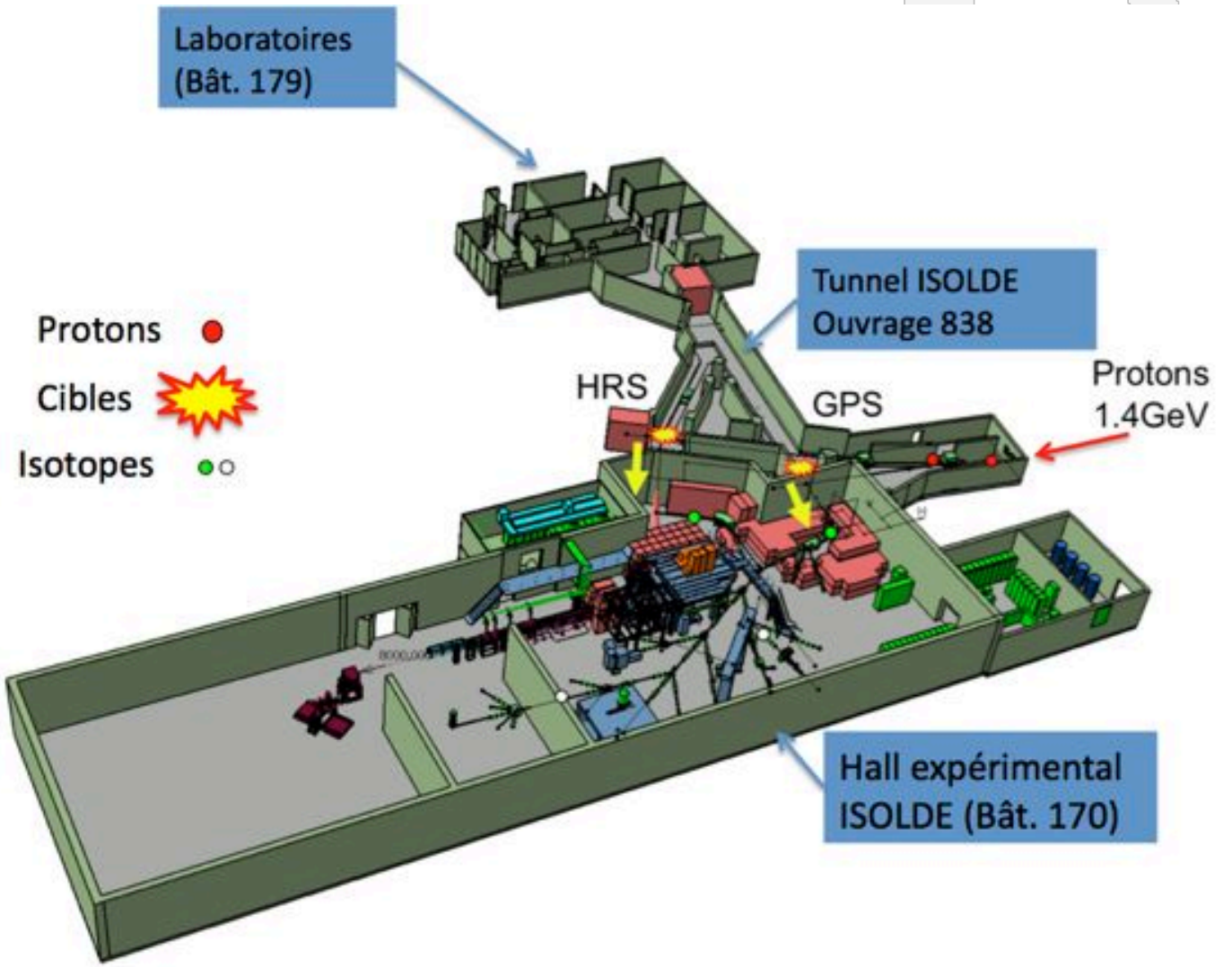
Outline

- Short description of ISOLDE
- ISOLDE target handling system (replacement project)
- Results of FLUKA calculations
- Conclusions and perspectives

CERN accelerators complex

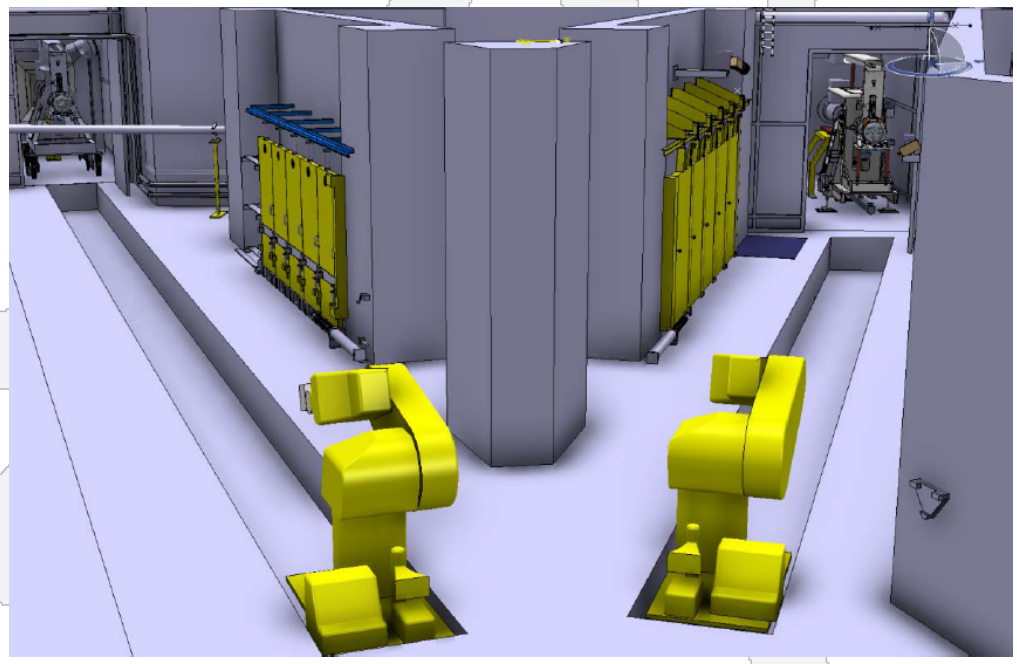


General layout of the ISOLDE facility



Current target handling system

- Two robots mounted on rails (located in a trench)
- Removal of targets and transportation to intermediate storage shelves and installation of the new target
- ~30 target exchanges performed per year



Target storage and hot cell project

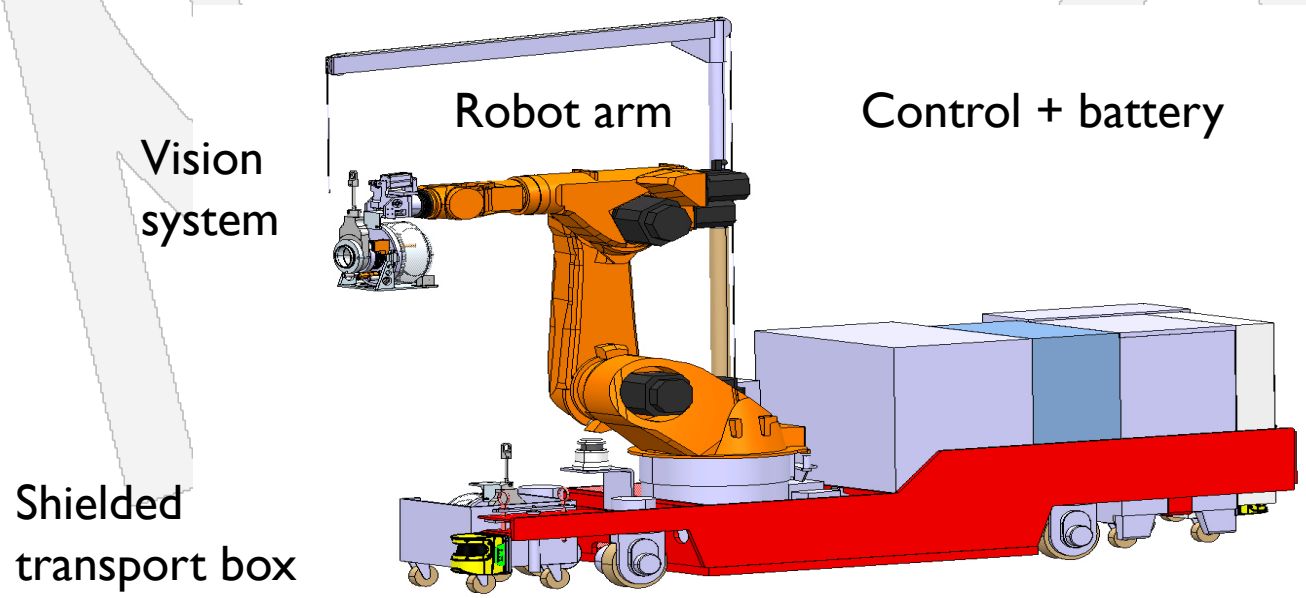
- Used targets transferred to a temporary storage area prior to maintenance activities during the shutdown
- Project to build a hot cell for target dismantling and conditioning prior to final storage.

Robot replacement project

- Current system arriving at the end of its lifetime and different concepts being investigated
  - One autonomous Automated Guided Vehicle (AGV) parked outside the target area during operation
  - Current concept (2 robots on rails) with some improvements
- Both approach have pros and cons: maintenance aspects, reliability, recovery procedure and flexibility have to be taken into account in the choice of the two concepts
- Monte-Carlo simulations (FLUKA) needed to assess the radiation environment in which the robot will evolve (radiation hardness, recovery scenario…)

Automated Guided Vehicle concept

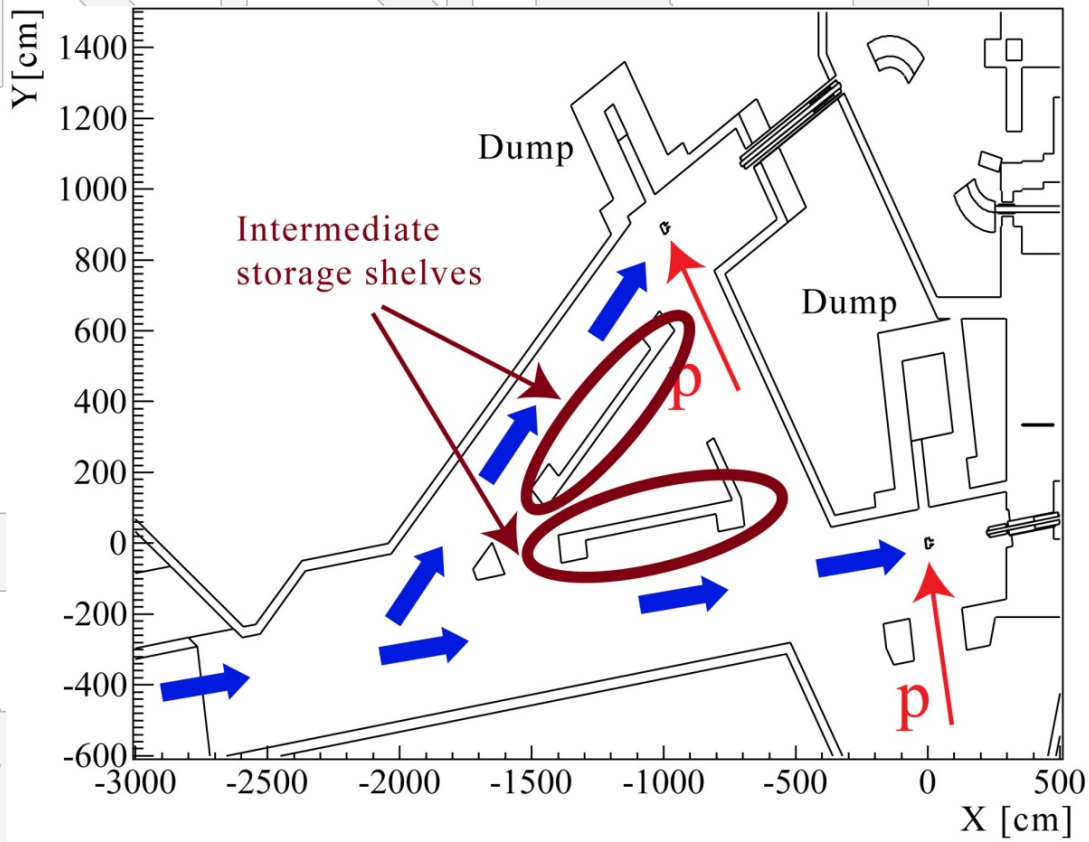
- Automated Guided Vehicle (AGV):
  - Fully autonomous vehicle
  - Integrated robot arm
  - Robot mounted vision system for precise robot control



Radiation impact and constraints (AGV)

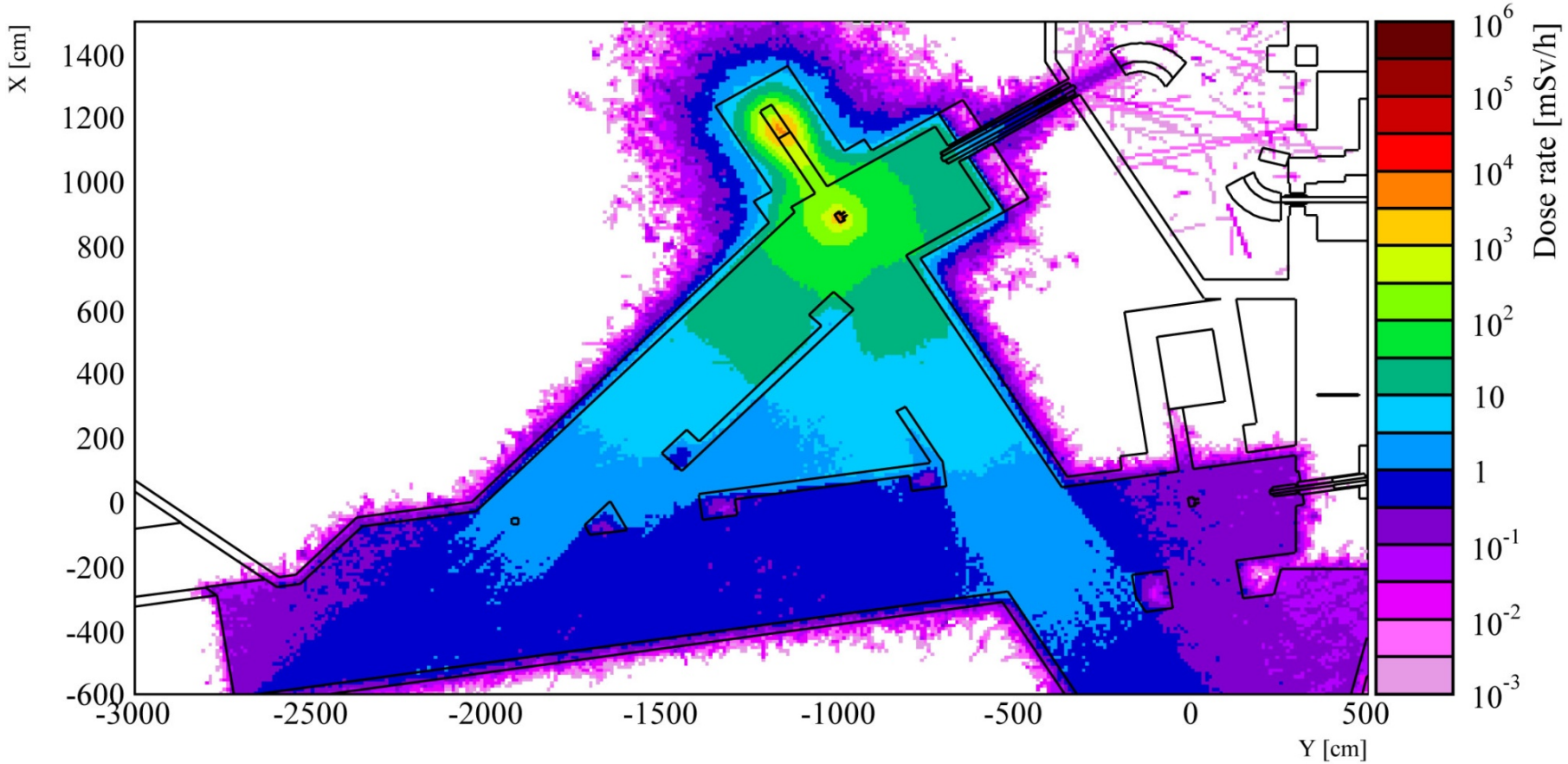
- Robot exposed to residual dose rate during target exchange:
  - Dose to vision system
  - Recovery
- 1×10^{19} protons over 220 h of operation
- UC target considered
- Different cooling times considered
- Cooling before target exchange = 3 days

FLUKA geometry of the area

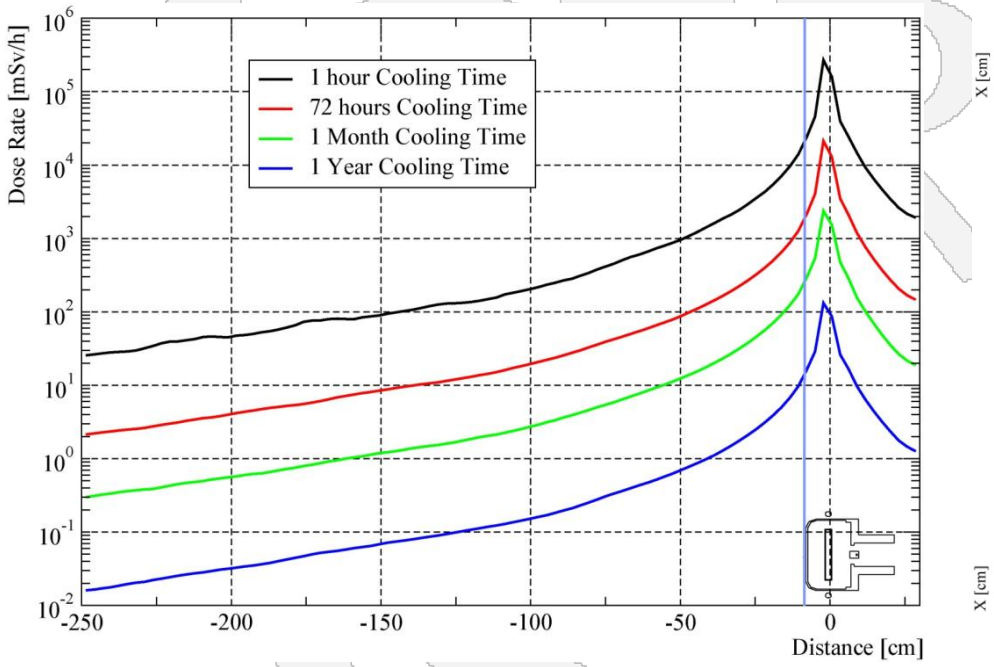


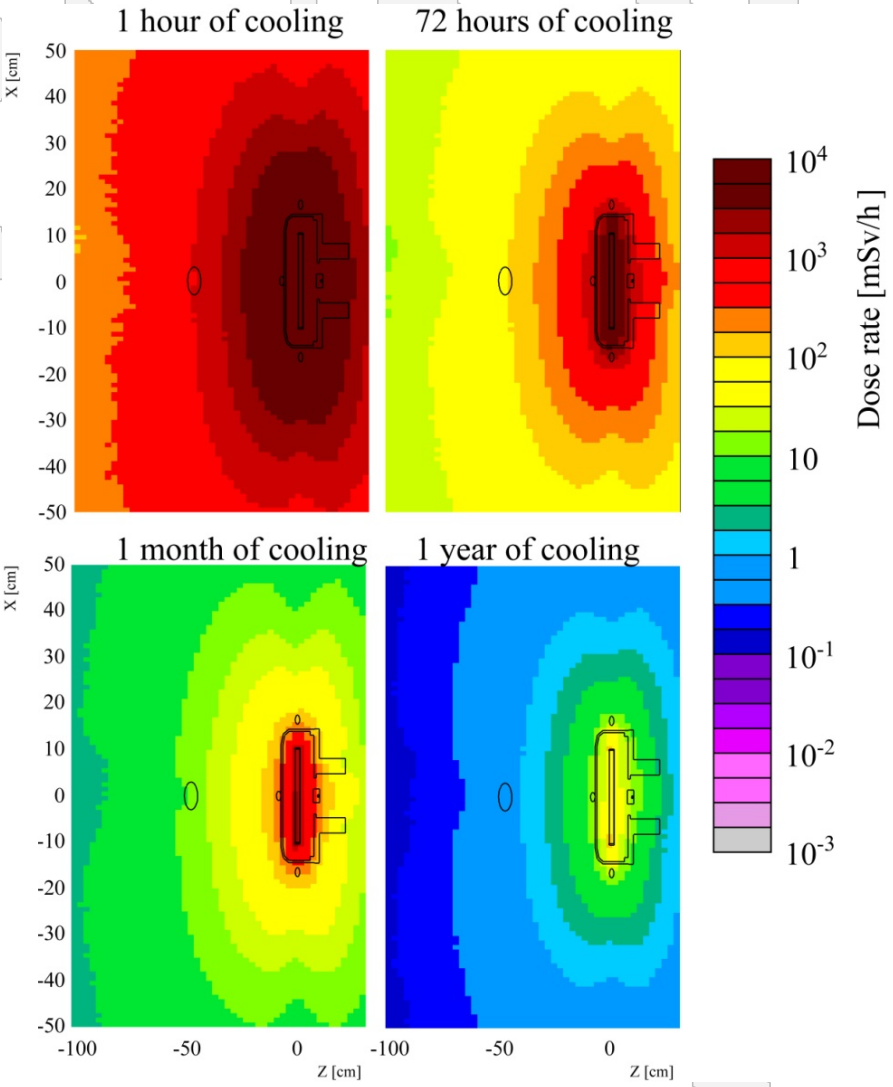
Example of residual dose rate map (72 h CT)

- Most of the beam absorbed in the beam dump (shielded)
- Several Sv/h on contact with the target (after 72 h of decay)
- No access above 100 mSv/h

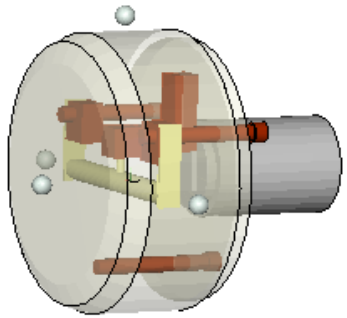


Close view of the target environment



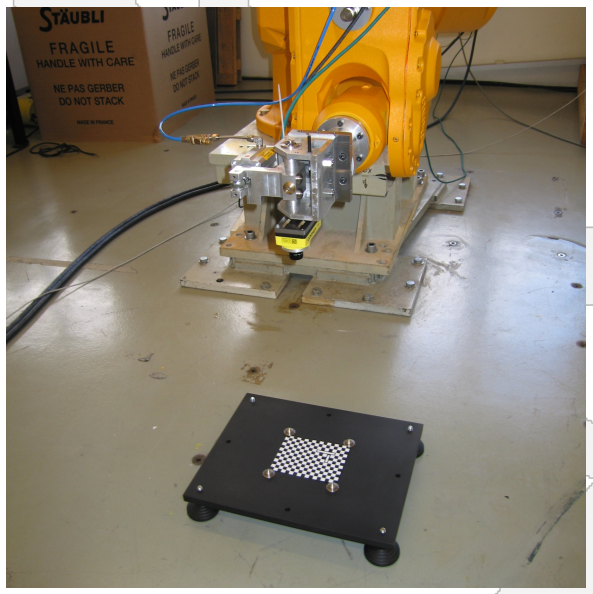


Gray/h close to the target from residual radiations

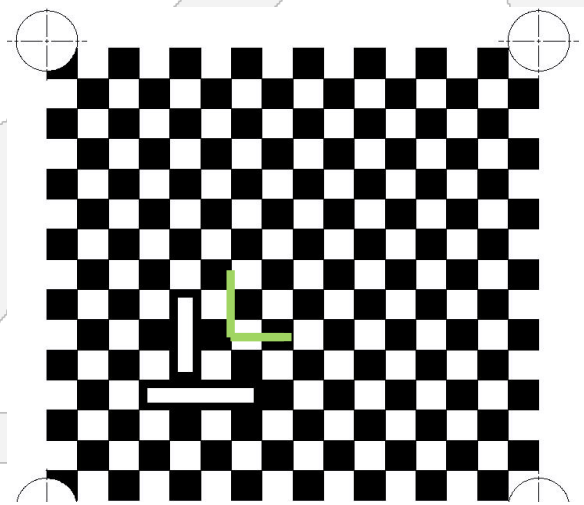


Dose to the vision/positioning system

- Vision system used for accurate robot positioning directly linked to system performance and reliability
- Envisaged CCD camera performance must be tested in similar radiation environment (illuminated exposure)
- To consider instantaneous and integrated dose effects

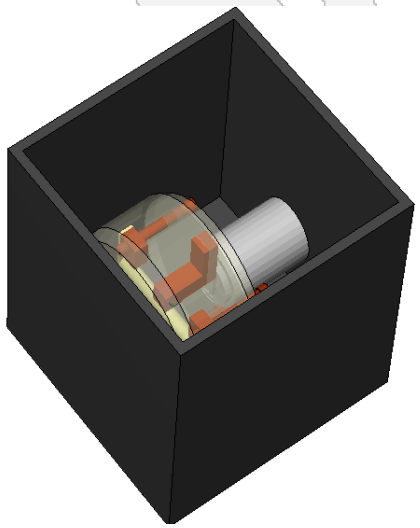


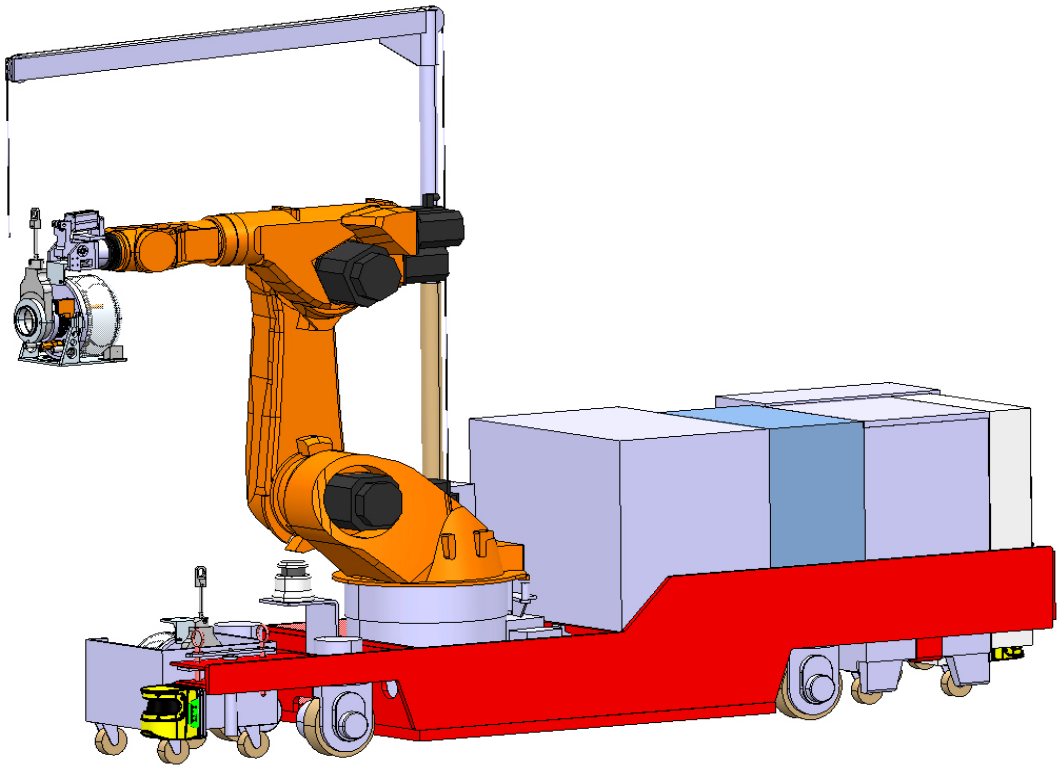
Camera calibration



Benefits from the shielded transport box

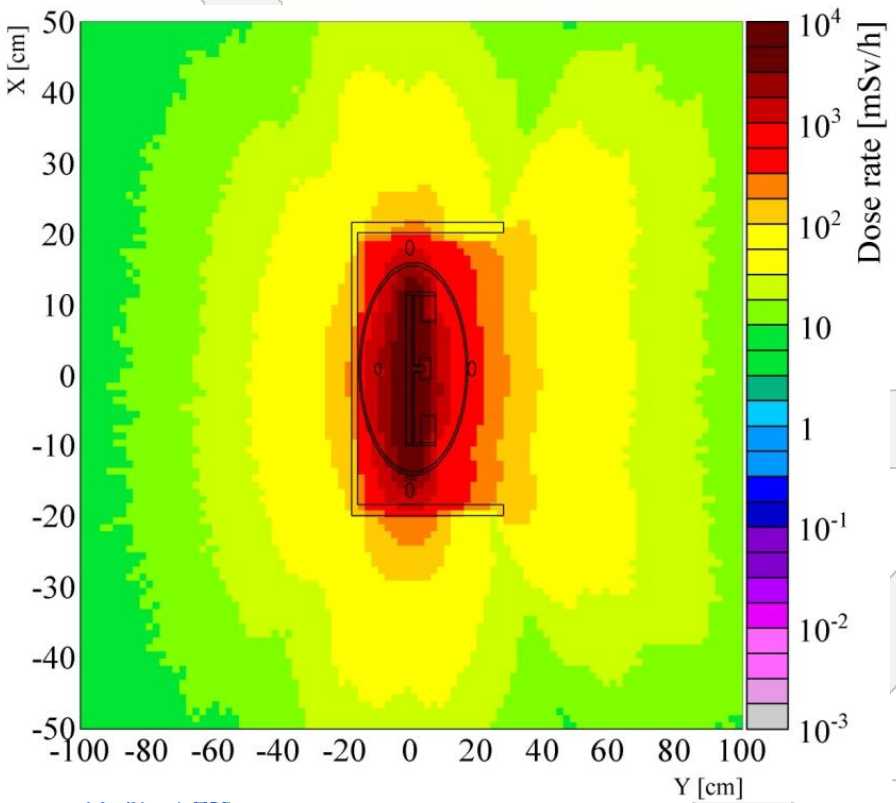
- Objective is to minimize the time during which used targets are handled with the robot gripper
- Transport box can be disconnected from AGV in case of failure

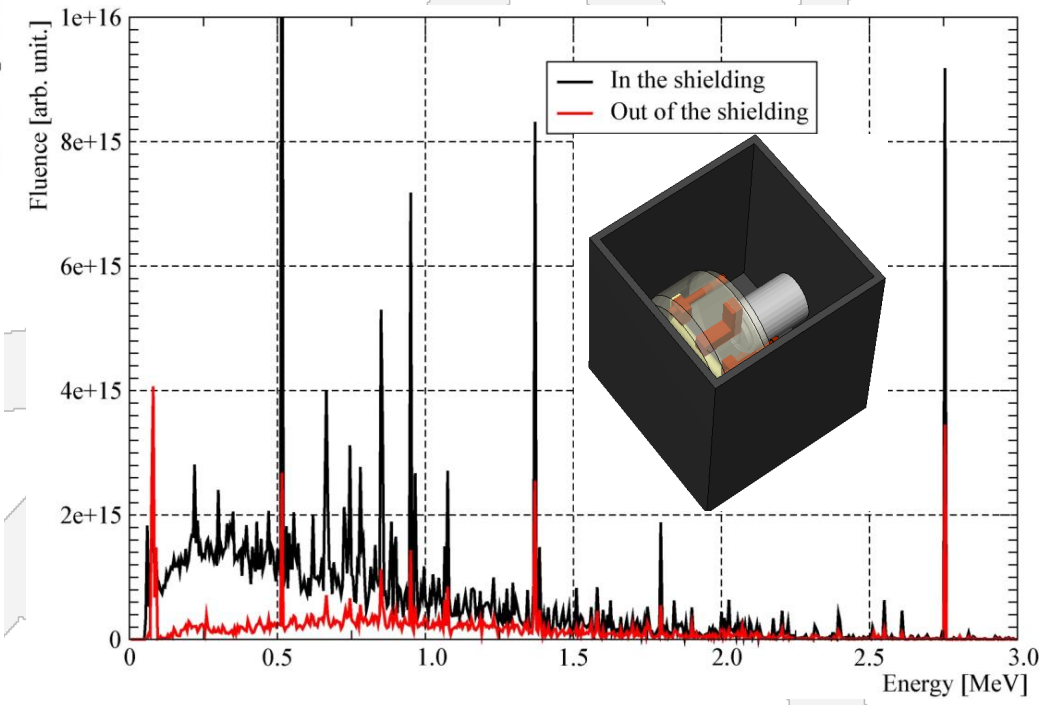




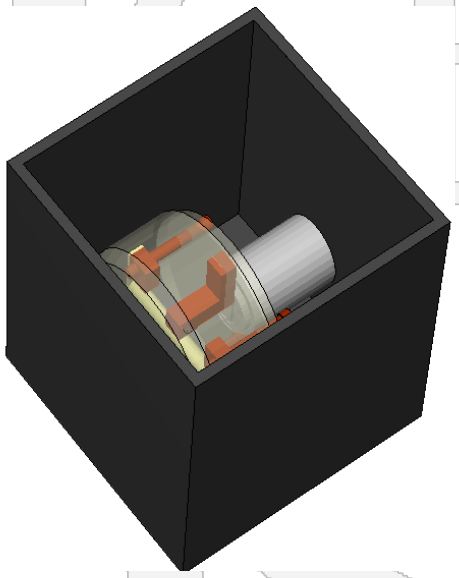
Calculations for the transport box

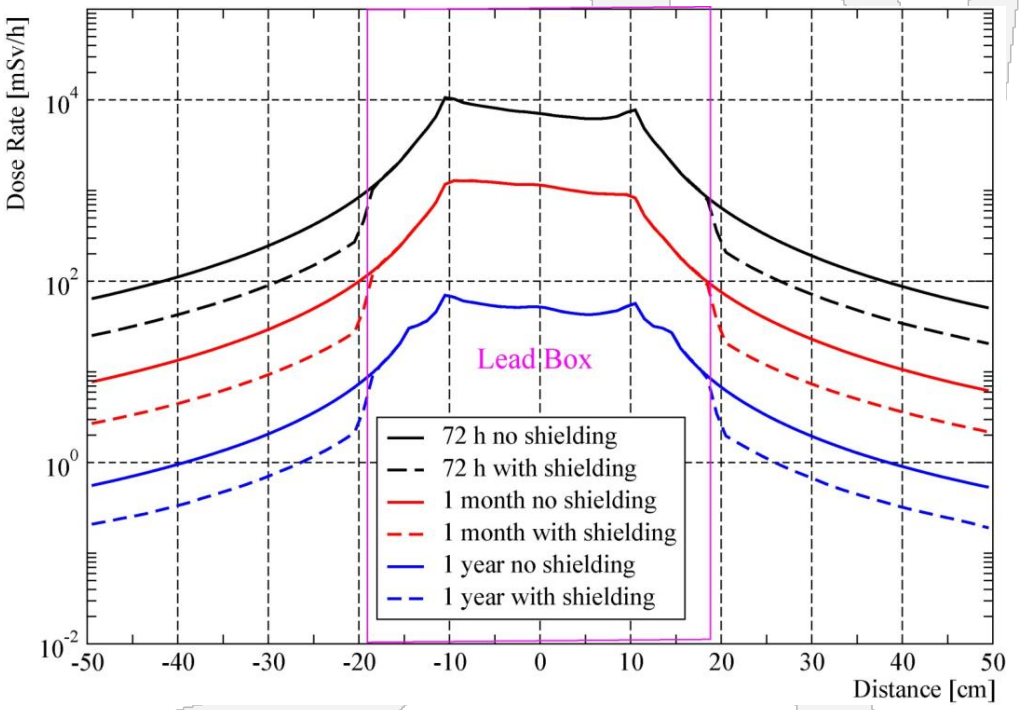
- Using a two steps approach where radioactive nuclei are "stored" in the first step and decay products transported in a different geometry during the second step





Residual dose rate for different CT

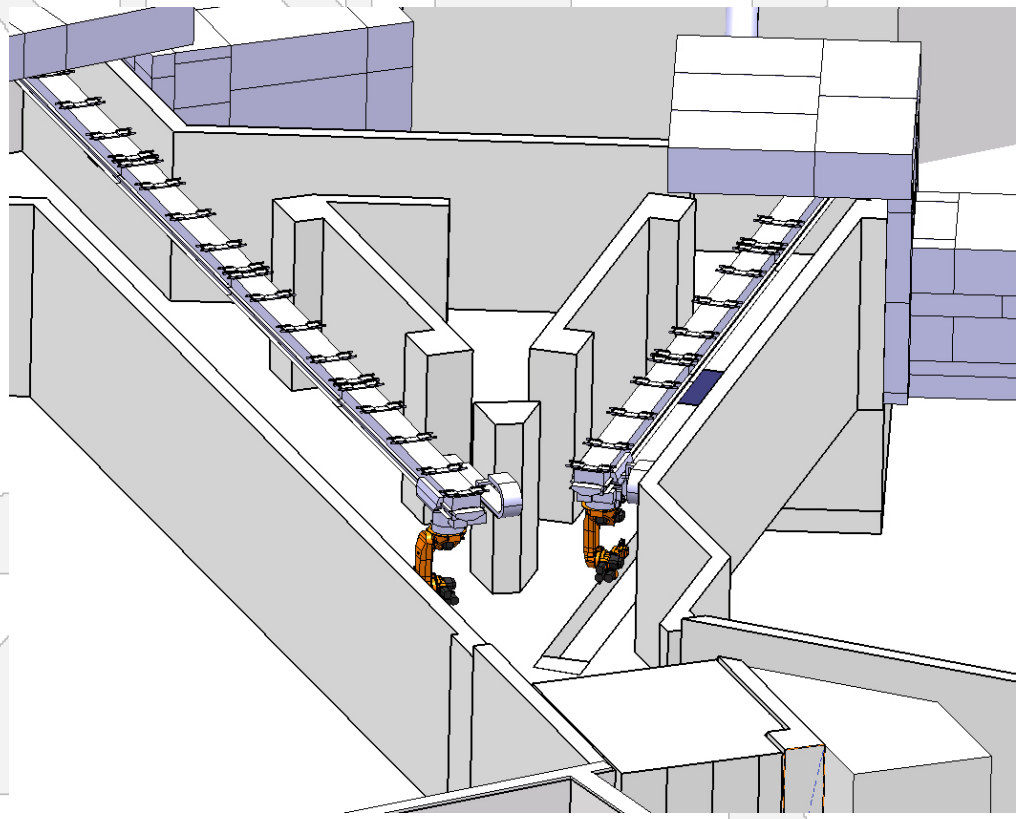




- Recovery could be complicated in case of failure (risk for operation - only one robot available)
- Dose to CCD camera for positioning system critical
- System is becoming quite complex and massive….

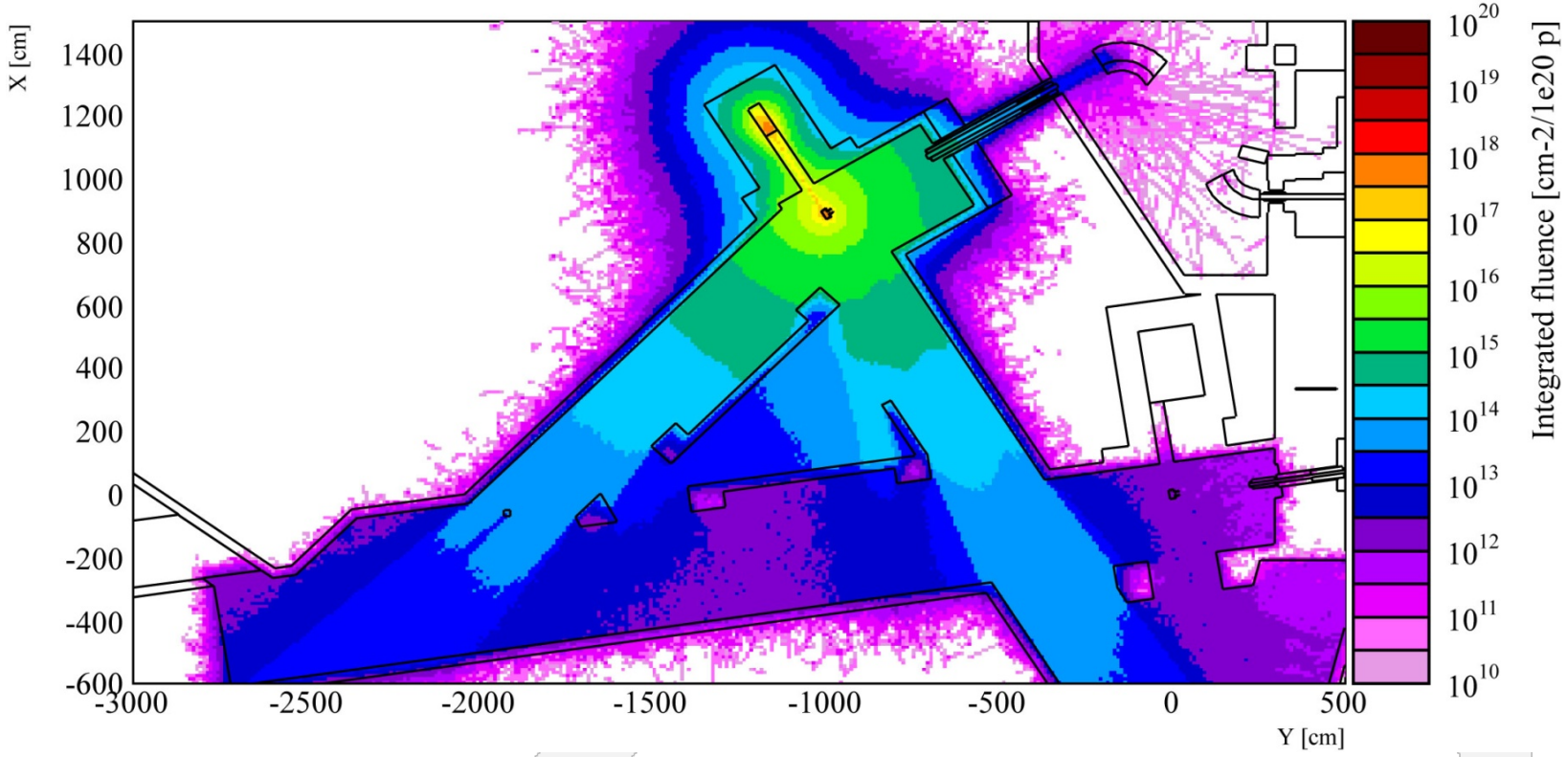
Alternative choice

- Similar system as the current one, except that the rail is mounted on the ceiling (avoiding trenches on the floor)
- Parked in the area during operation
- Controls located outside
- Benefits from current technology
- Sensitivity to radiation damage ?
- Calculation of radiation environment (cumulative effects)



Calculation for the most exposed robot

- Scoring the 1 MeV neutron equivalent fluence (probability of displacement damage in Si due to NIEL)
- Scoring of dose (deposited energy) for organic components
- Results used for the technical specification



Consideration for radiation hardness

- Integrated dose for organic material of the order of kGy per year (calculations results in agreement with TLD passive dosimetry measurements). Important for festoon cables.
- 1 MeV neutron equivalent fluence considering planned accelerator upgrade of the order of 10^{14} n/cm^{-2} per year
- Recommended to minimize electronic components inside the primary area (better for maintenance purpose as well)
- No issue with Single Event Upset as robot is off during beam operation

Summary and Conclusions

- FLUKA calculations of the residual dose rate around ISOLDE targets performed in the frame of the ISOLDE robot replacement project
- AGV option seems to be complicated (vision/AGS/robot) and not optimal from a reliability point of view (one robot + long cooling time for recovery)
- Similar concept as the one used today seems to be preferred with some improvements
- FLUKA calculations very useful for other target handling aspects (hot cell project for used targets dismantling, isotope inventory for risk analysis….)

Aknowledgements

- R. Luis and Y. Romanets for providing the FLUKA geometry used for those calculations