The ISOLDE Robot Incidents

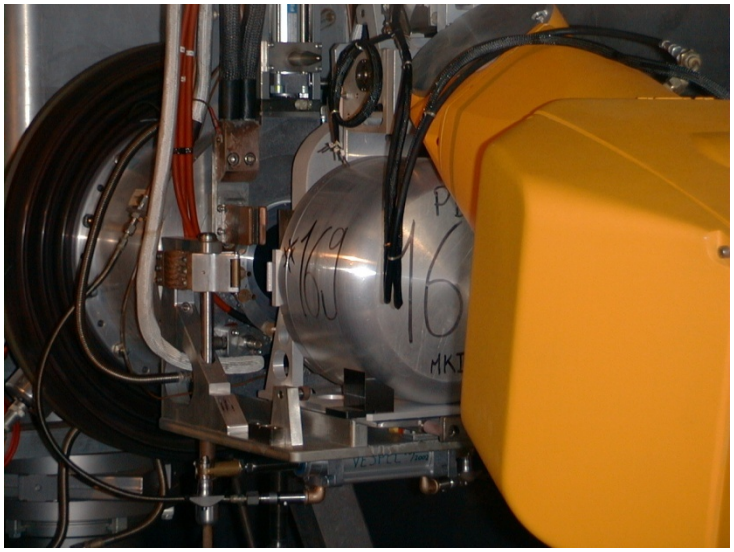
Richard Catherall EN-STI-RBS

Reports

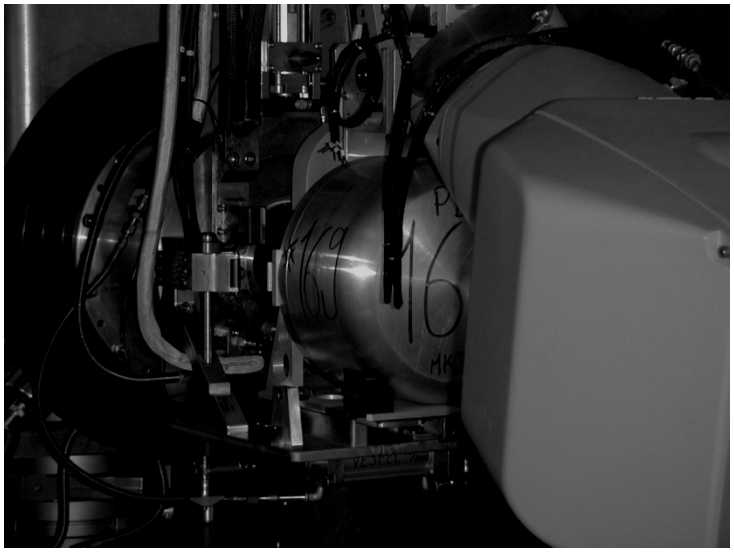
- 20th July: Failure of GPS robot while trying to place target at shelf position.
- 29th July: Failure of robot to remove target #405 from HRS Front End.
  - Situation restored in extremis
  - Cause unknown
  - Target removal tested 2 times and robot/target/FE interface deemed OK for future operation.
- 13th August: Failure of robot to remove target #407 from HRS Front End.

13th August Incident

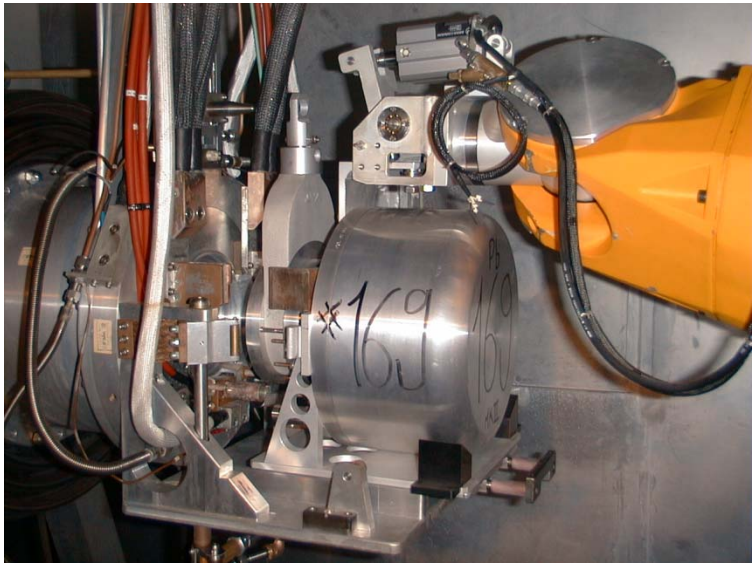
- Robot trips out when trying to retrieve target from HRS Front End
  - Error message “gripper failed to close”
  - Robot cycle will not continue if one action in the sequence has failed
- R. Catherall investigates and requested access for visual inspection and photo.
- Target already uncoupled so precautions for an open radioactive source were required.
  - Overalls, mask with filter etc
- Estimated time in situ: 30 seconds



View from ~3 meters in situ



Simulated monitor view



Correct target pick up

Target #407 failed pick-up

13th August Incident contd.

- Obvious that target/FE/robot interface jammed…worst case scenario.
  - Robot does not grip target handle, possibility of target falling if robot is retrieved.
- Tried to open grip and retrieve robot remotely but unsuccessful due to poor visibility.
- Abandoned after ~1 hour. The risk of generating further damage or worsening the situation was too high.

- Decided to prepare for a manual intervention the following day:
  - To allow for further radioactive decay
  - To eliminate possible causes due to target manufacture – investigation at workshop, change of contractor.
  - To minimize delays in physics schedule.
- An intervention plan was sent out to all those directly concerned.

Intervention Plan

- Bonjour,
- As you may well know, the HRS robot is currently blocked at the Frontend with a radioactive target with a dose rate of 160 mSv/h at 10 cm (measured at 10:00 this morning and with a half life of ~18 hours). I have tried to separate them remotely but without 360 degree vision the operation was becoming more of a liability and risked to cause more damage. The scenario now is to stop physics tomorrow (Friday 14th August) and intervene manually in order to restore the situation. Until the problem is understood we will no longer be able to take protons on the HRS this year. EN-STI-RBS have excluded the possibility of the target geometry being the cause of these problems. The cause can only be identified by closer inspection.
- The intervention plan for tomorrow is as follows:
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- 07:30: Protons off (Users)
- 08:00: Switch to Access mode. (BE-OP). Do not switch to access mode immediately after stopping protons else the radiation monitors may generate an alarm.
- 08:15: Arrival at 179 of M. Owen, A. Dorsival, S. Marzari, R. Catherall
- 08:30: Access
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- In situ: Richard and Stefano will release the robot from the target, leaving the target #407 on the FE. Estimated time 2 mins. Distance between 40cm and 150cm.
- Remotely: Richard will drive the robot back to its home position. 10 mins
- In situ: Michael will remove target from FE manually and place it at a shelf position. Estimated time 15 seconds. Distance 10cm.
- In situ (at FE without target): Stefano and Richard will inspect the coupling table of the Front End. (**We have our suspicions concerning the magnet for the pre-defined position and the rollers for target displacement)**. Time 2 minutes. Distance ~40 cm.
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- If there is a problem with the coupling table, it will be repaired by Stefano and Richard. Time 5 – 10 minutes. After which a clean target will be placed and removed from the FE remotely but with the presence of Richard in situ. Time 2 x 1 minute.
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- If there is no problem with the target coupling table **the robot will have to be checked and re-programmed as follows**;
- Place new target on FE with robot and observe in situ by Richard. Time 1 minute
- Remove target and observe in situ by Richard. Time 1 min
- Re-program robot approach parameters in robot control room. Richard
- Repeat steps 1 to 3 until satisfied.
- Help from BE-OP in running the robot would be most appreciated.
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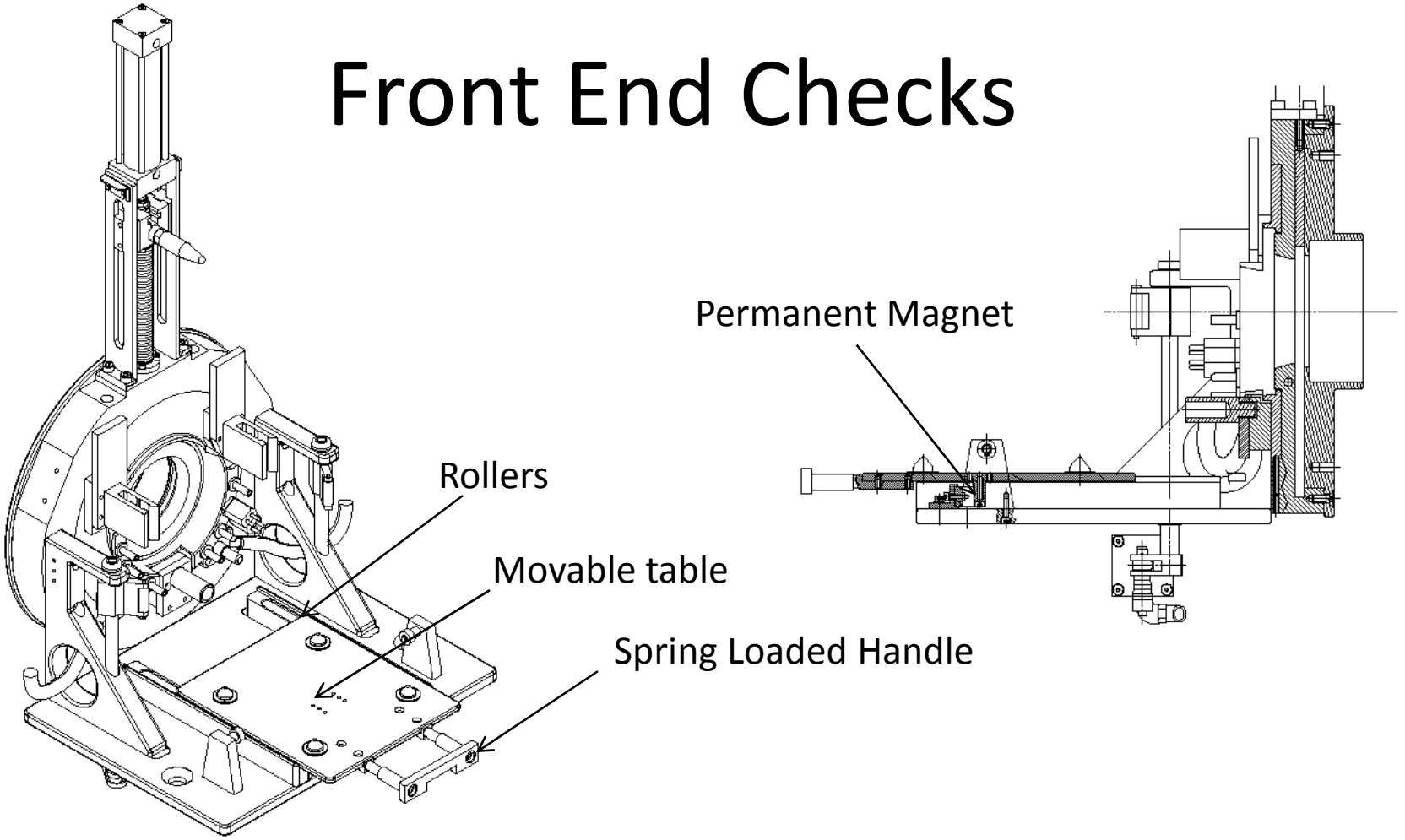
- Finally, as in previous failures during target changes, we do not relish such interventions. The robot/target/FE interface is the responsibility of EN-STI-RBS and we will do our best to restore the situation as soon as possible. Once repaired we will report on the cause and actions taken during the intervention and take measures to prevent its re-occurrence.
- Best regards
- Richard

Release and storage of target

- Intervention by R. Catherall, S. Marzari and M. Owen in the presence of A. Dorsival (RP)
- Manual release of robot motor brakes in situ whilst simultaneously release target from grip.
  - Estimated time → 2 mins at 40cm and 150 cm
  - Real time → 28 seconds
- Robot moved away from critical area remotely.

- Transport of target to storage shelf
  - Estimated time → 15 seconds
  - Real time → 10 seconds

Front End Checks



- Situation found to be OK but could be improved.
- Table, rollers, handle and permanent magnet replaced

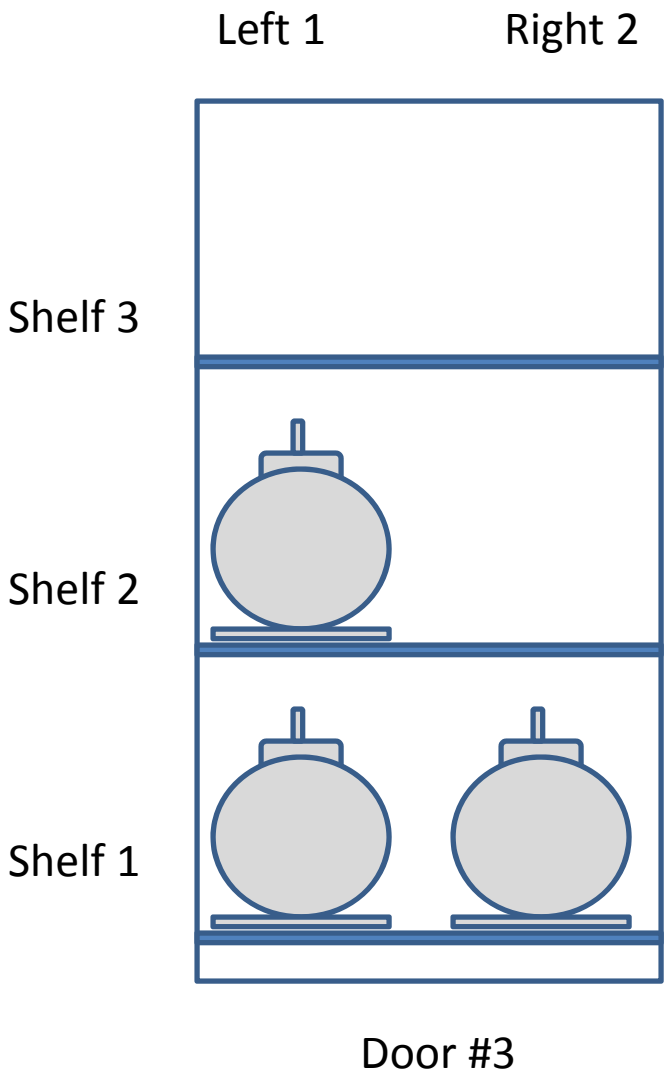
Robot Checks

- Robot programmed to place and remove non-radioactive target while RC observes in situ.
- Process to be repeated until modification of programs acceptable.
  - Estimated time in situ per operation → 1 min
  - Real time ~30 seconds per operation
  - 7 operations required.
  - Dose rate at 40cm between 4mSv/h (BTY side) and 12mSv/h (beam dump)

- Observation: The finger on the robot gripper was barely touching the spring loaded handle when pulling the target to the pre-defined position.
- Consequence: Any friction or when beyond tolerance of the robot movement (+/- 0.5mm), the robot would fail to pull the target table to its correct position.
- Probable cause: Ground movement/creep. ~1-2mm over ~7 years.
- Action: Robot gripper pulling height parameter lowered by ~2 mm.

GPS – a separate incident

Pre-programmed pick and place cycle
Pre-defined locations
E.g. Take target from Front End to door position 322
Incident occurred because 321 coordinates were saved as position 322.
Human error? Overwritten values…Save as!!
Program manipulation error, software?
Action:
- Do not use this shelf position this year.
- Test other shelf positions without target before use.
- Re-program robot correctly during next shutdown.



Summary of doses received

Person	GPS µSv	HRS 1 µSv	HRS 2 µSv	Total per person µSv
R. Catherall EN-STI	131		1568	1699
P. Fernier BE-OP		430		430
M. Owen EN-STI			375	375
S. Marzari EN-STI			298	298
A. Dorsival SC-RP			64	64
P. Carbonez SC-RP	11	38		49
T. Stora EN-STI		130		130
M. Eriksson BE-OP			5	5
Total per incident	142	598	2310	

Conclusions

- Robot situation at HRS restored – but at a certain cost in terms of radioactive dose.
- GPS robot problem known. Precautions to be taken for the rest of this year and to be remedied during the shutdown.
- The results of the tests after the first incident at the HRS were misleading as the limit at which the finger was pulling the handle could not be observed correctly. It was by chance that the two tests succeeded.