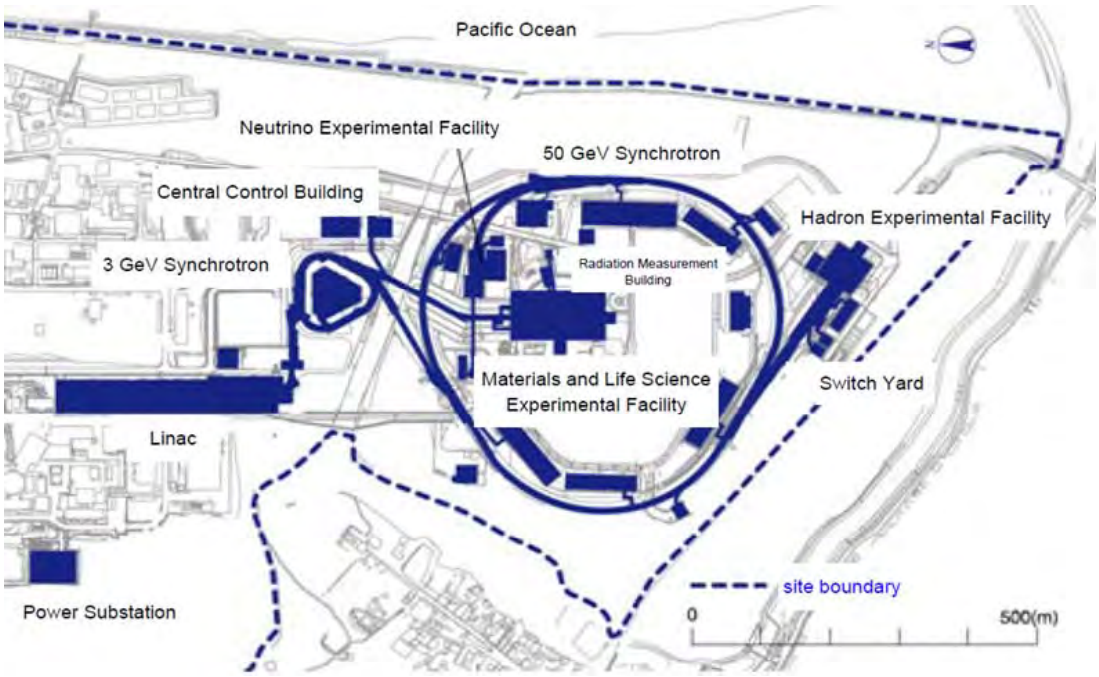
Appendix 3

Investigation on the Gold Target

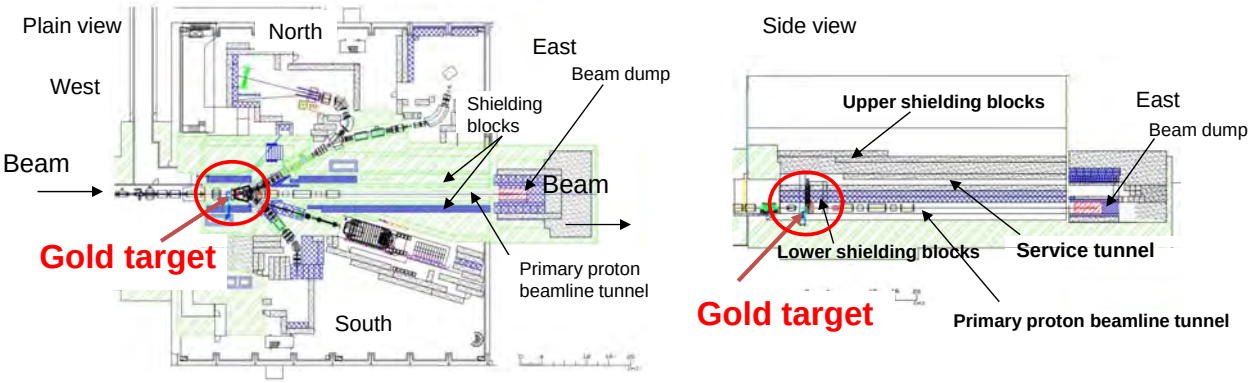
July 2013

J-PARC Center

J-PARC Facilities Layout



Overview of the Investigation



- A large number of protons were delivered to the gold target within an unexpectedly short period (5 milliseconds). As a result, it is considered that the gold target was damaged and radioactive material leaked out from the target assembly area into the Hadron experimental hall (HD hall) and also outside the boundaries of the radiation controlled area of the Hadron Experimental Facility (HD Facility).

- To determine the cause(s) of this accident, we need to directly observe the gold target by using a fiberscope or other methods in close proximity.

Preparation for the Investigation (1/2)

- The gold target is housed in a primary beamline tunnel in the HD hall. The tunnel is covered by shielding blocks made of concrete or steel. For observation, it is necessary first to remove the shielding blocks above the gold target to make an opening for a fiberscope.
- It is known that the radioactive material has leaked into a tunnel of the 50 GeV synchrotron that is adjacent to the primary beamline tunnel of the HD hall.
- To prevent further spread of the radioactive material, the investigation is planned as follows:

(Step 1)

By continuously circulating the ambient air in the tunnel through the activated charcoal filters to be newly installed, reduce the concentration of radioactive material in the air as much as possible.

Note: most of the radioactive nuclides observed right after the accident have decayed by now, and the dominant airborne radioactive material in the tunnel, at this moment, is iodine-125 (^{125}I). Activated charcoal filters act as a very effective trap for ^{125}I.

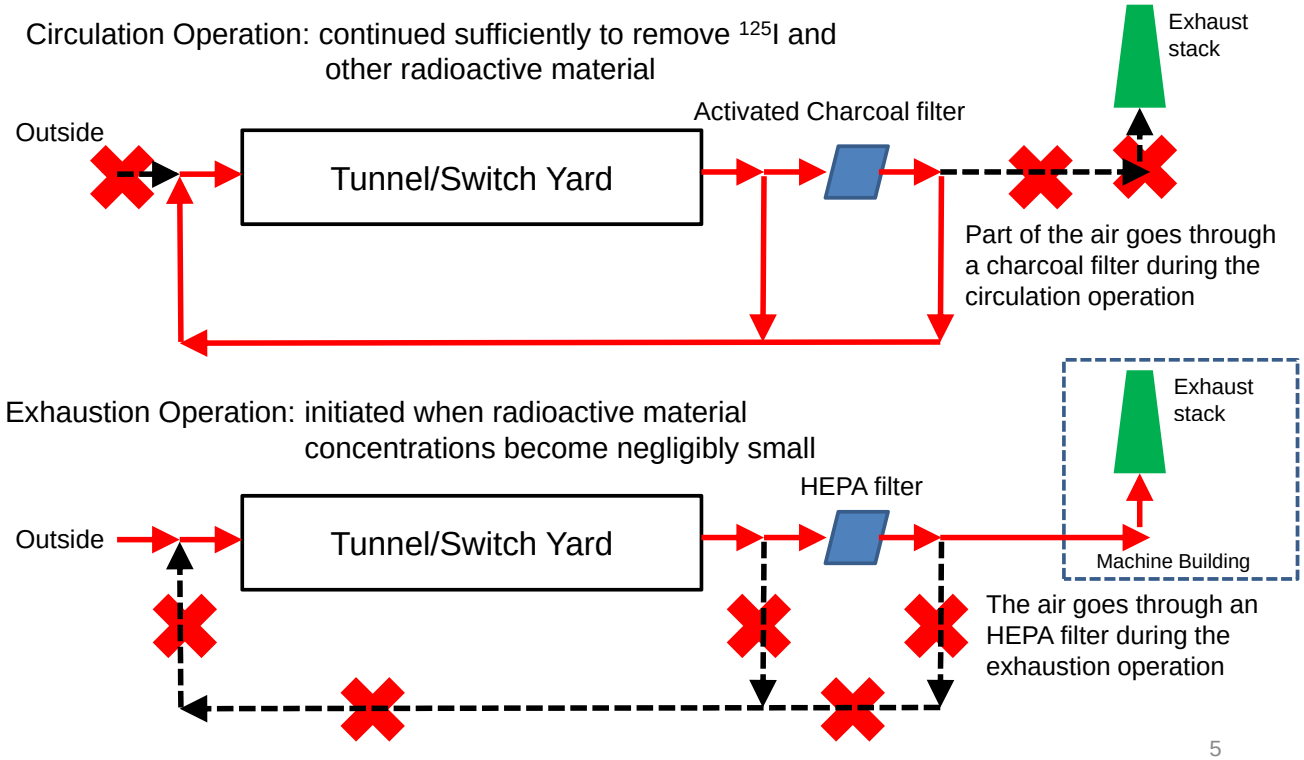
(Step 2)

After confirming the radiation level to be sufficiently low in the tunnel, the tunnel air will be exhausted through HEPA (High-Efficiency Particulate Air) filters installed at MR Machine Buildings No.1, 2 and 3 and Hadron Machine Buildings No.1 and 2. During this process the radiation level will be monitored.

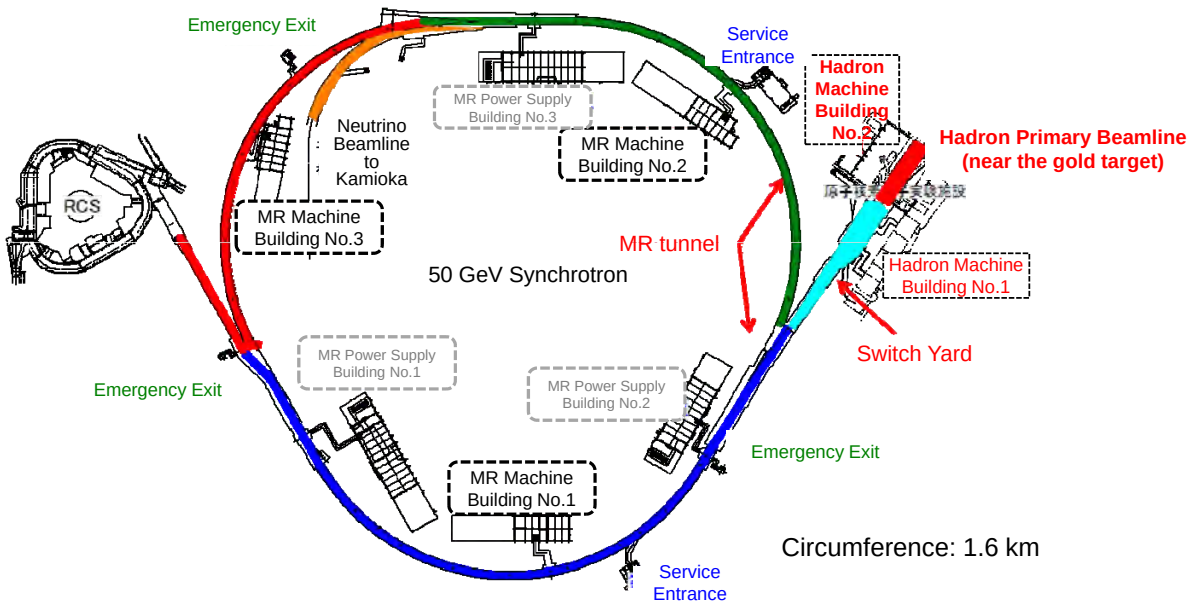
Note: After the accident, the HD hall has been re-classified as a class 1 radiation controlled area and a strict curfew has been imposed against leakage of any radioactive material from the building.

Preparation for the Investigation (2/2)

Schematic Diagrams of Filtering Procedures



Locations of Machine Buildings



Concentration of Radioactive Material in the Tunnels

Table 1: Concentrations of radioactive material in air samples from the tunnels (Bq/cm^3)

	50 GeV Synchrotron Tunnel	Primary Beamline Tunnel of HD Hall
^{125}I	4.1×10^{-7}	1.4×10^{-4}

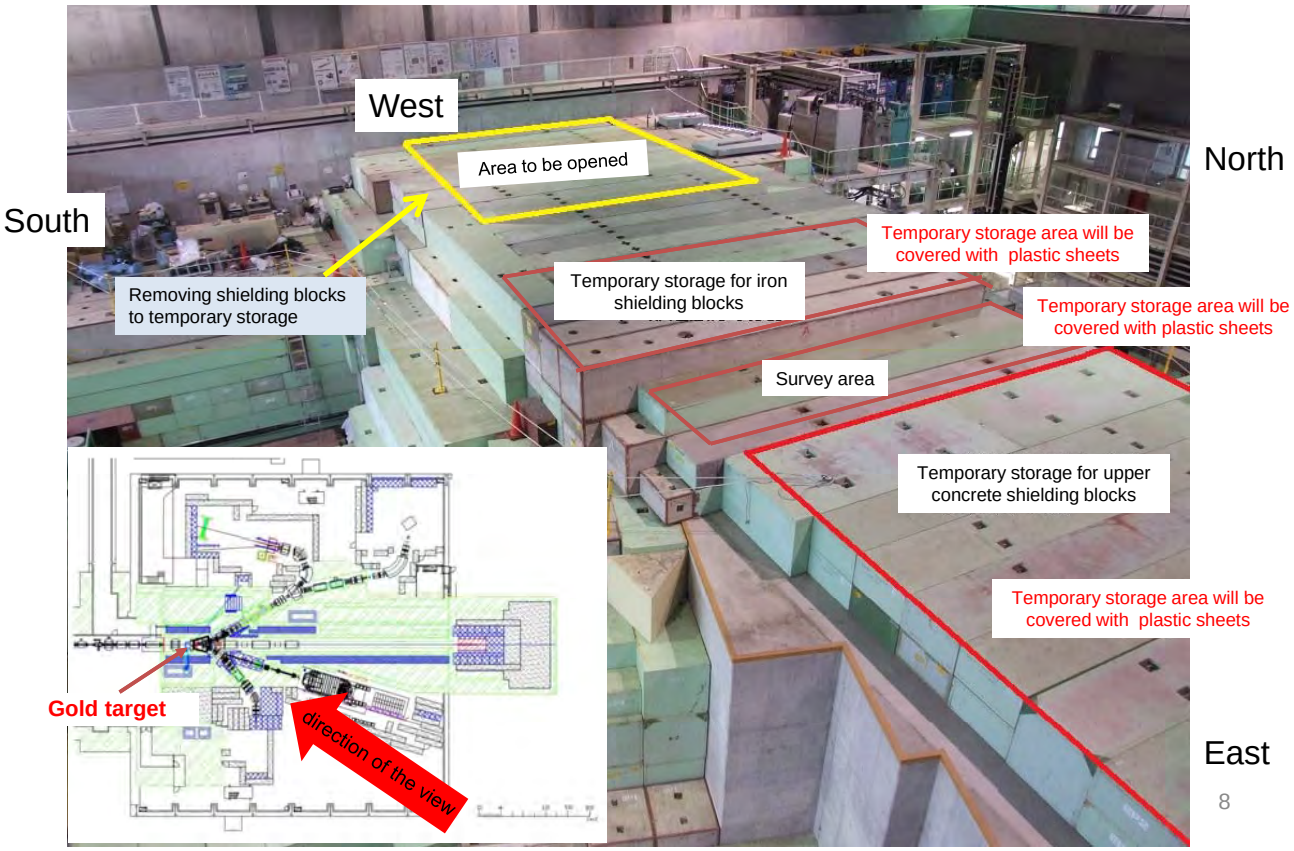
Table 2: Estimated concentrations of radioactive material in the exhaust air, averaged over 3 months, when the air in the tunnel is exhausted as it is(Bq/cm^3)

	50 GeV Synchrotron Facility	Hadron Experimental Facility
^{125}I	7.3×10^{-11}	1.1×10^{-8}

Legal limit of the maximum concentration of ^{125}I in the exhaust air: 8×10^{-6} Bq/cm^3

- Table 2 shows the averaged concentrations of radioactive material in an exhausted air when air exhaustion is continued for 3 months as it is. The averaged concentrations are expected to be well below the legal limit.
- Before the tunnel air go through a usual exhaustion route, we will use activated charcoal filters to further lower the concentration on case.
- Exhaustion of the air from the tunnel won't start unless the airborne radiation level there to become sufficiently low. The air will be discharged through HEPA filters at MR Machine Buildings No.1- No.3 and Hadron Machine Buildings No.1 and 2 while monitoring the radiation levels to ensure that they stay below the legal limit.
- ^{125}I is most of the radioactive nuclides observed right after the accident have decayed by now and the dominant airborne radioactive material in the tunnel at this moment. Activated charcoal filters act as a very effective trap for ^{125}I.

Procedure to open a gap by moving radiation shielding blocks above the gold target



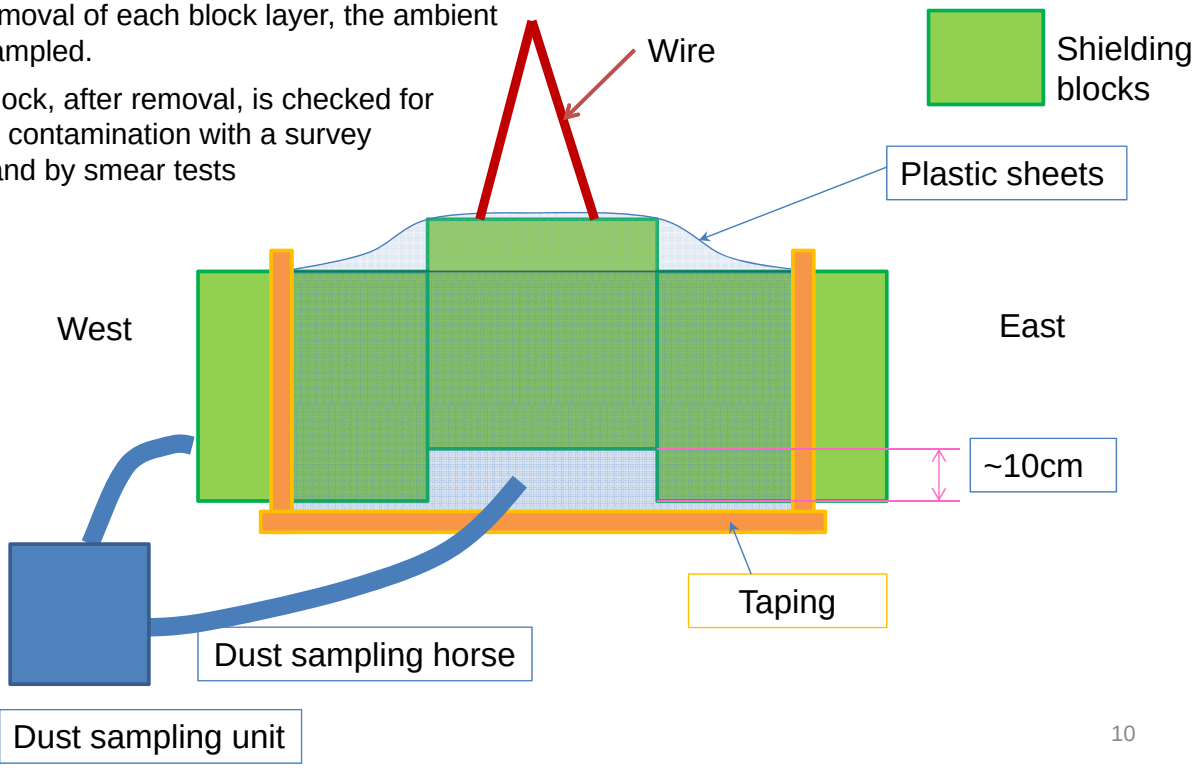
Removal procedure of radiation shielding blocks

- Utmost care is taken to prevent the spread of contamination and to ensure the safety for all workers.
  - Radiation shielding blocks: with removal of each block layer, the surface contamination is surveyed and the ambient air is sampled.
  - Workers wear a special protection gear and a mask.
  - Plastic sheets are used everywhere to prevent the spread of contamination.
  - Use of air purifiers.
  - Use of portable air exhaust systems.

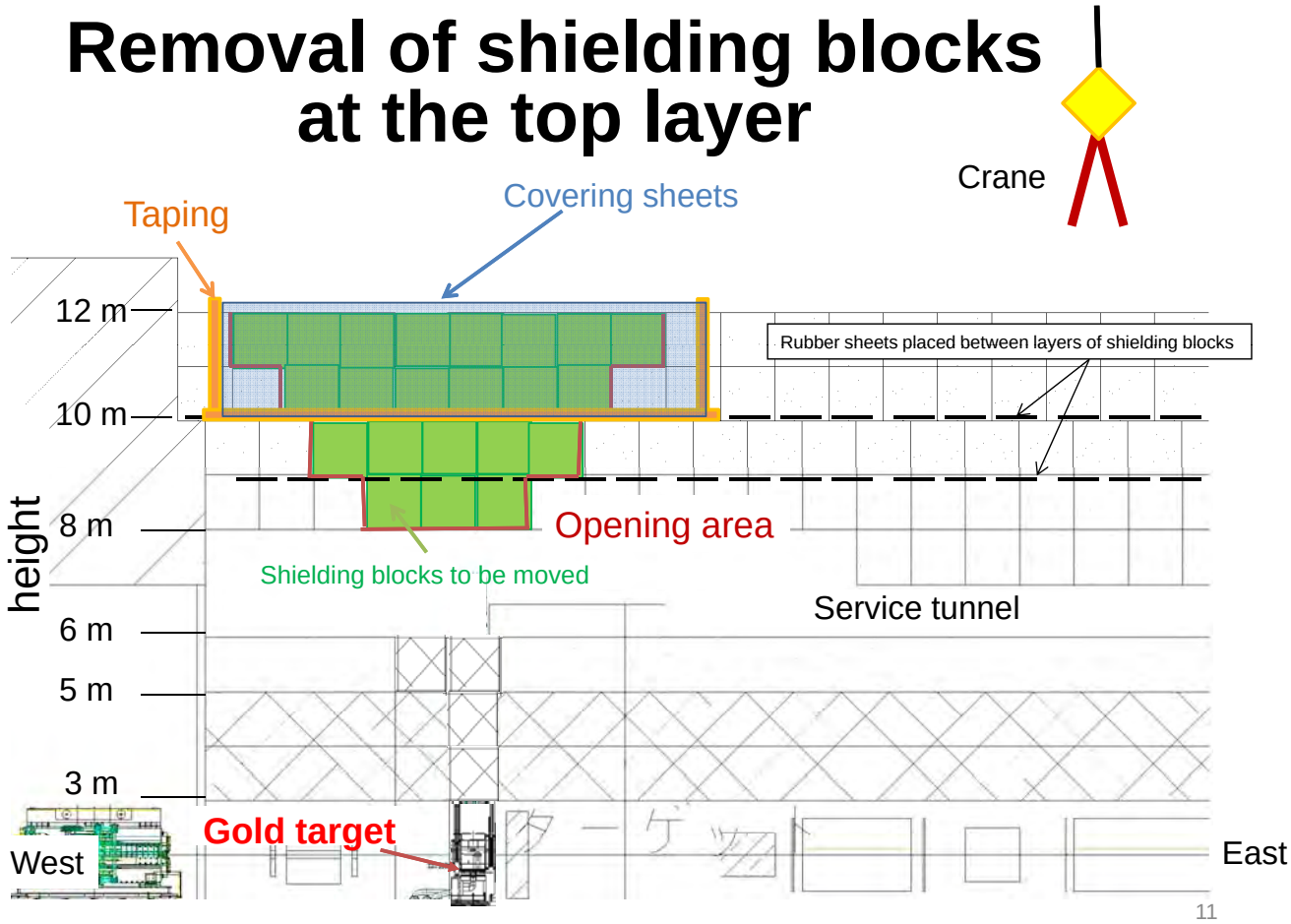
Removal of shielding blocks at the top layer

With removal of each block layer, the ambient air is sampled.

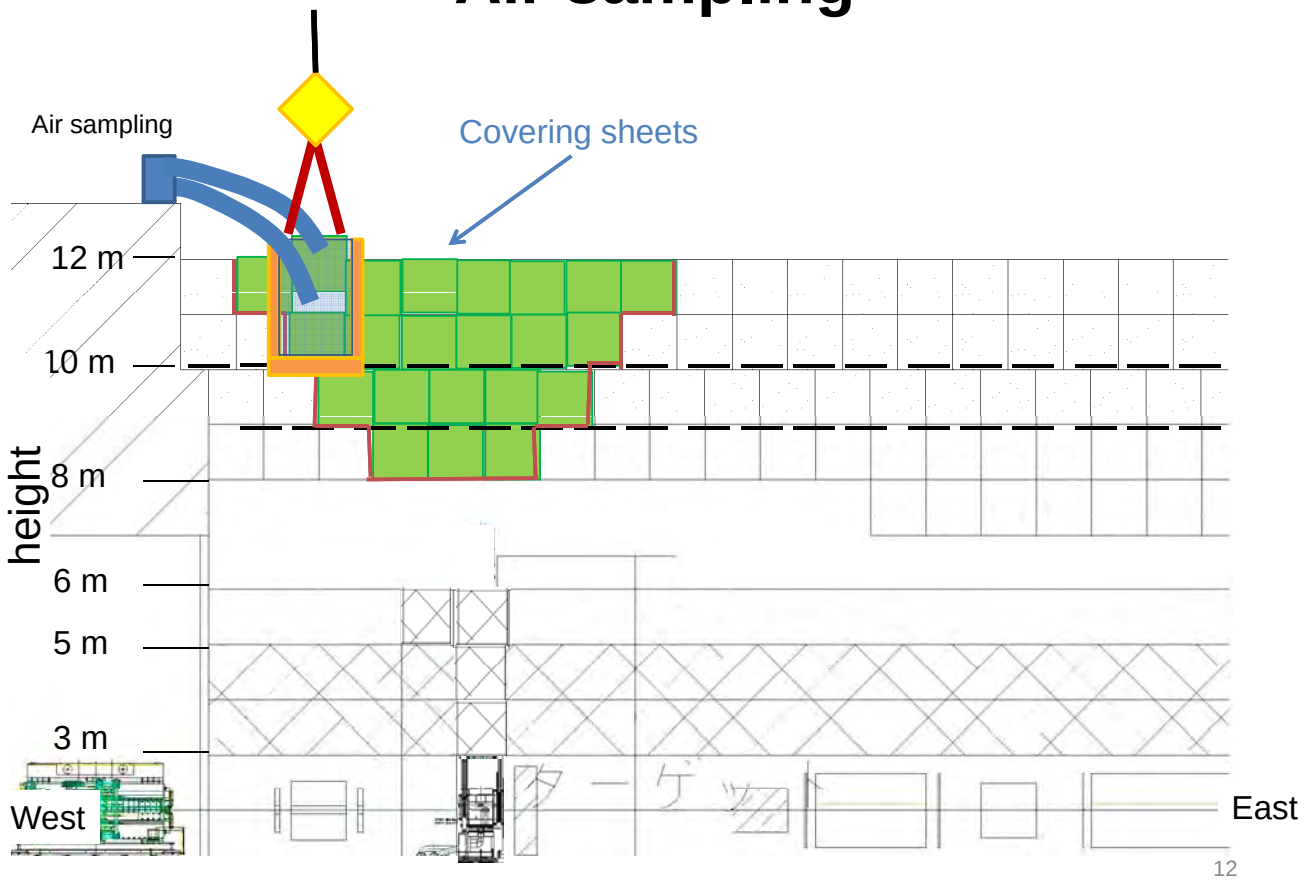
Each block, after removal, is checked for surface contamination with a survey meter and by smear tests



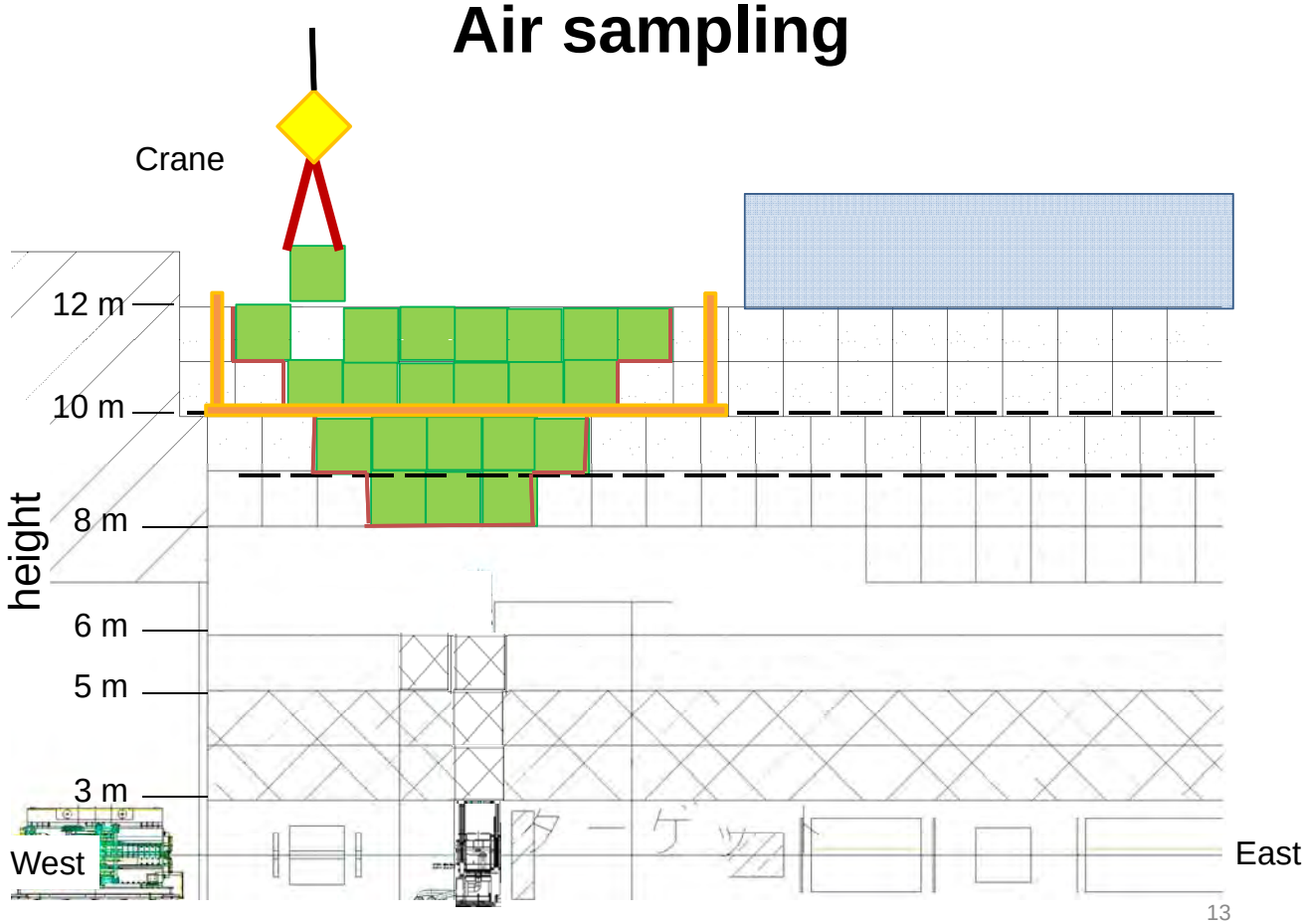
Removal of shielding blocks at the top layer



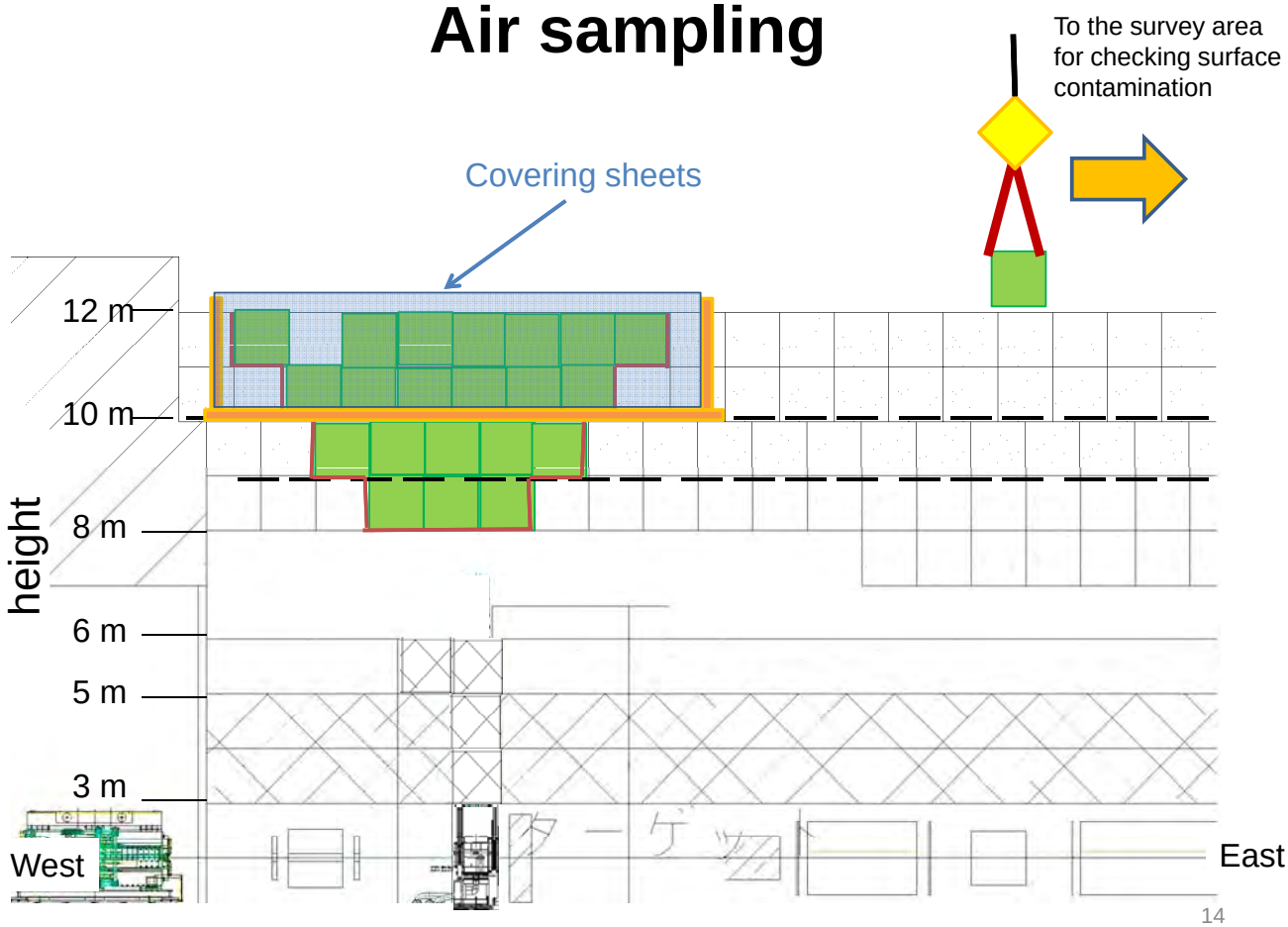
Air sampling



Air sampling

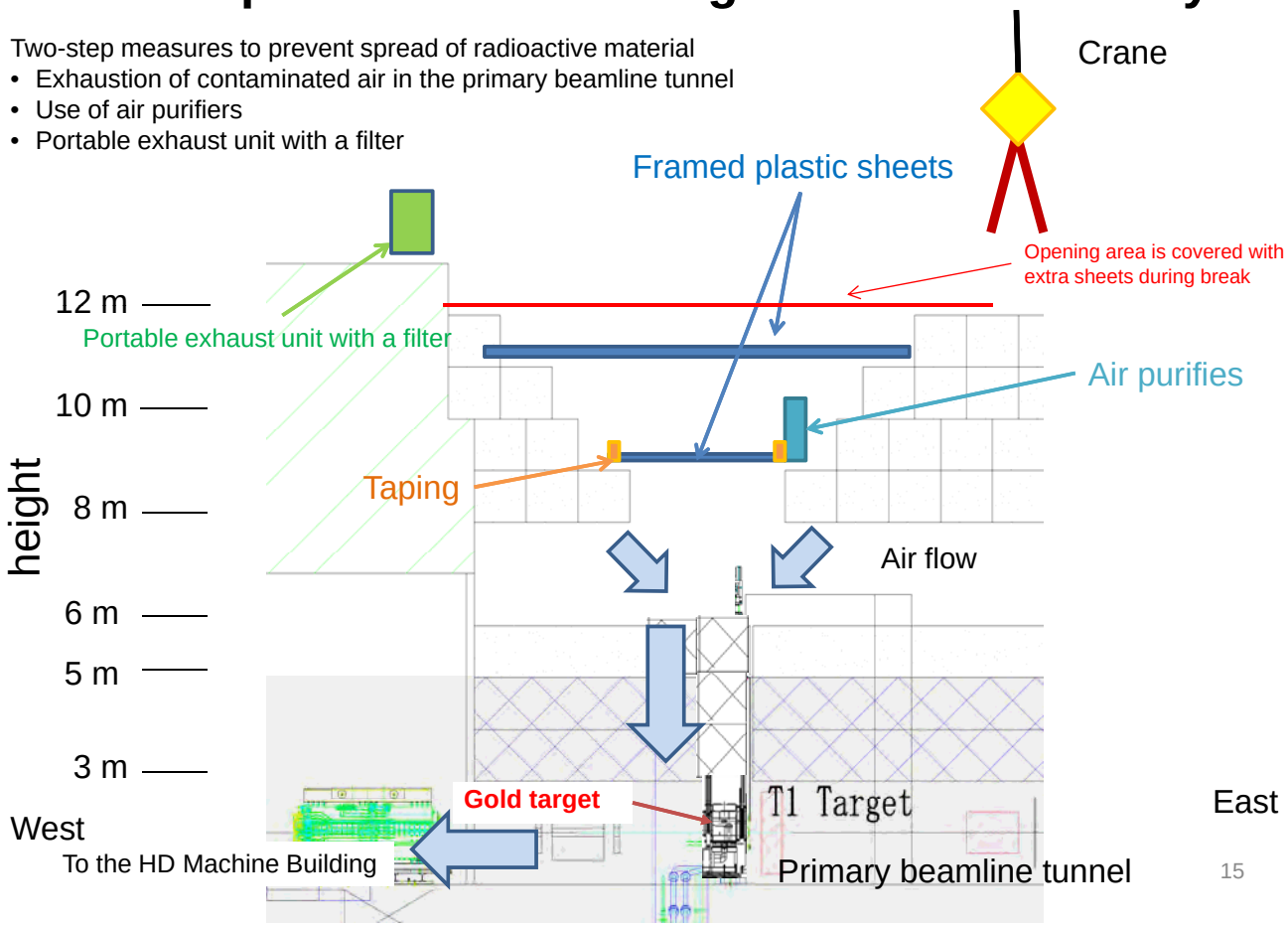


Air sampling

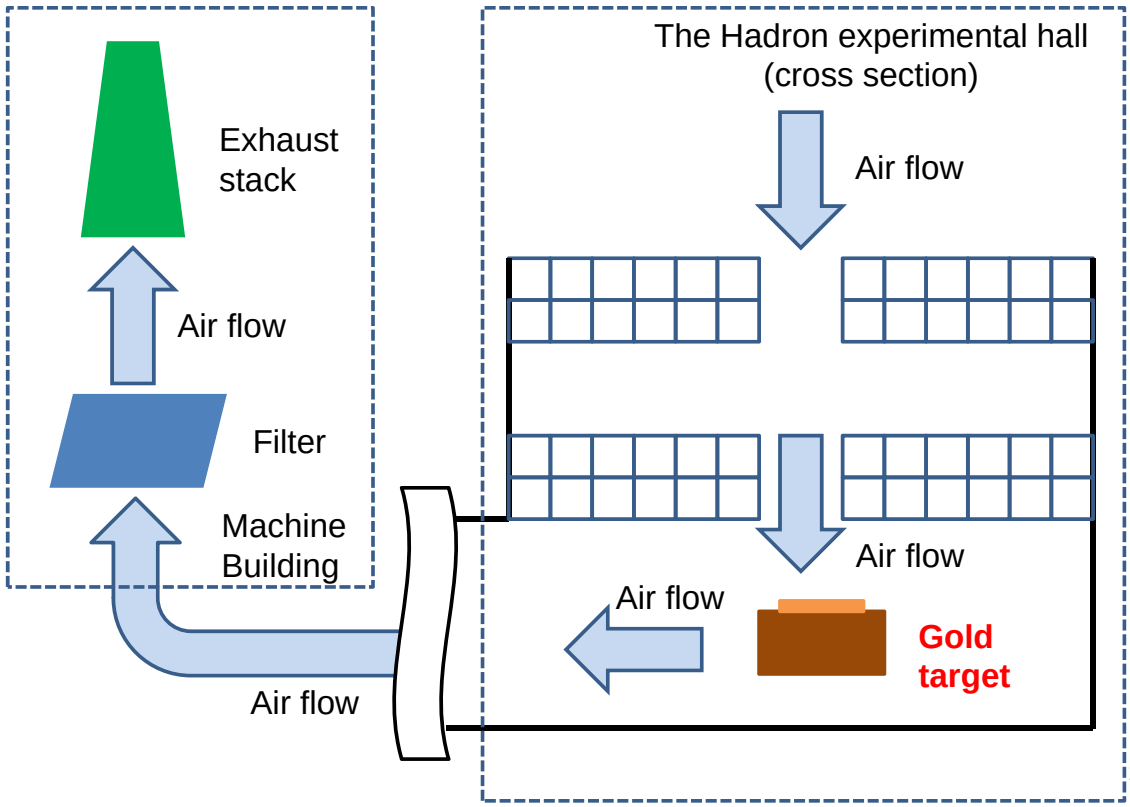


Removal process of shielding blocks of lower layers

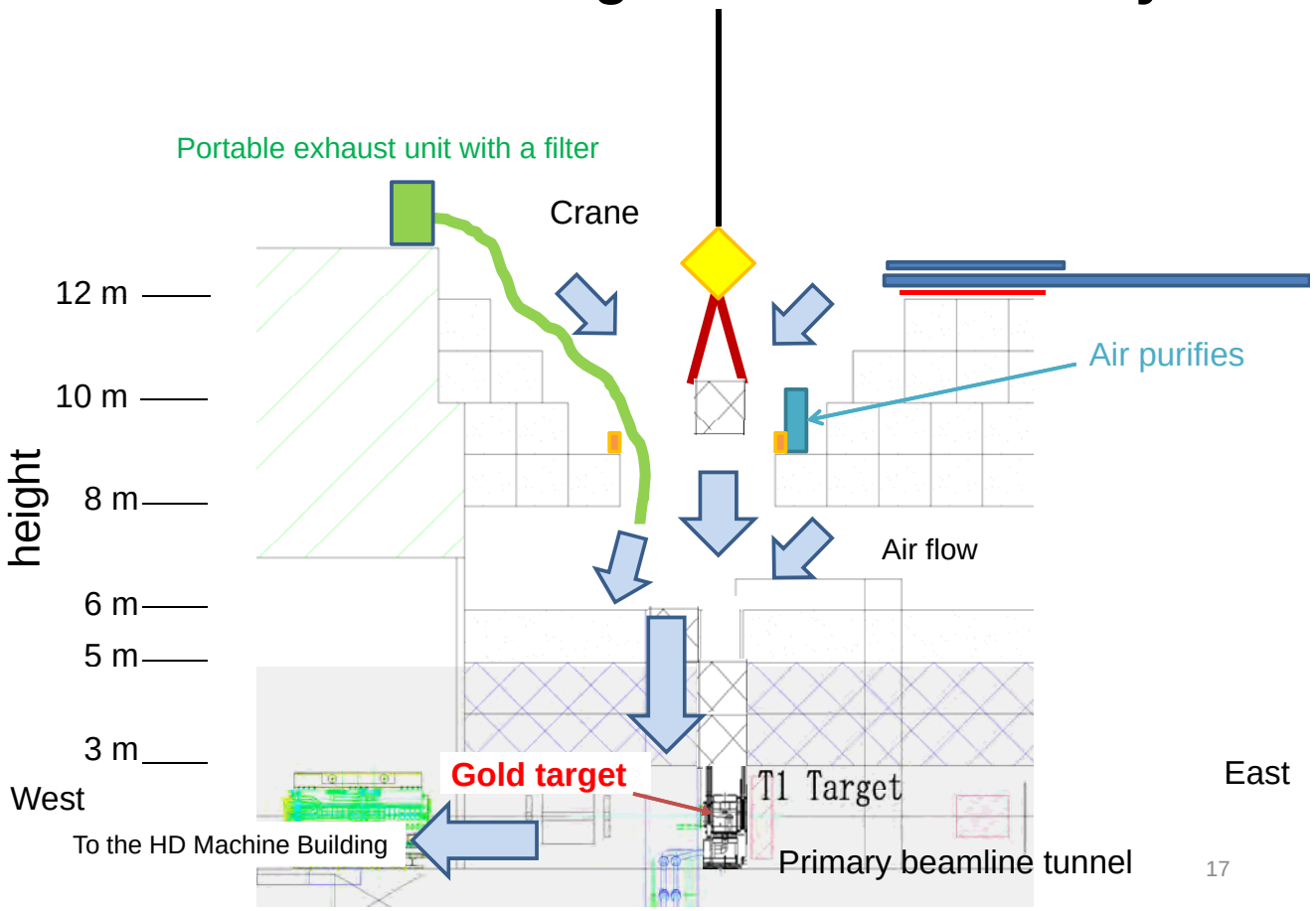
Two-step measures to prevent spread of radioactive material
- Exhaustion of contaminated air in the primary beamline tunnel
- Use of air purifiers
- Portable exhaust unit with a filter



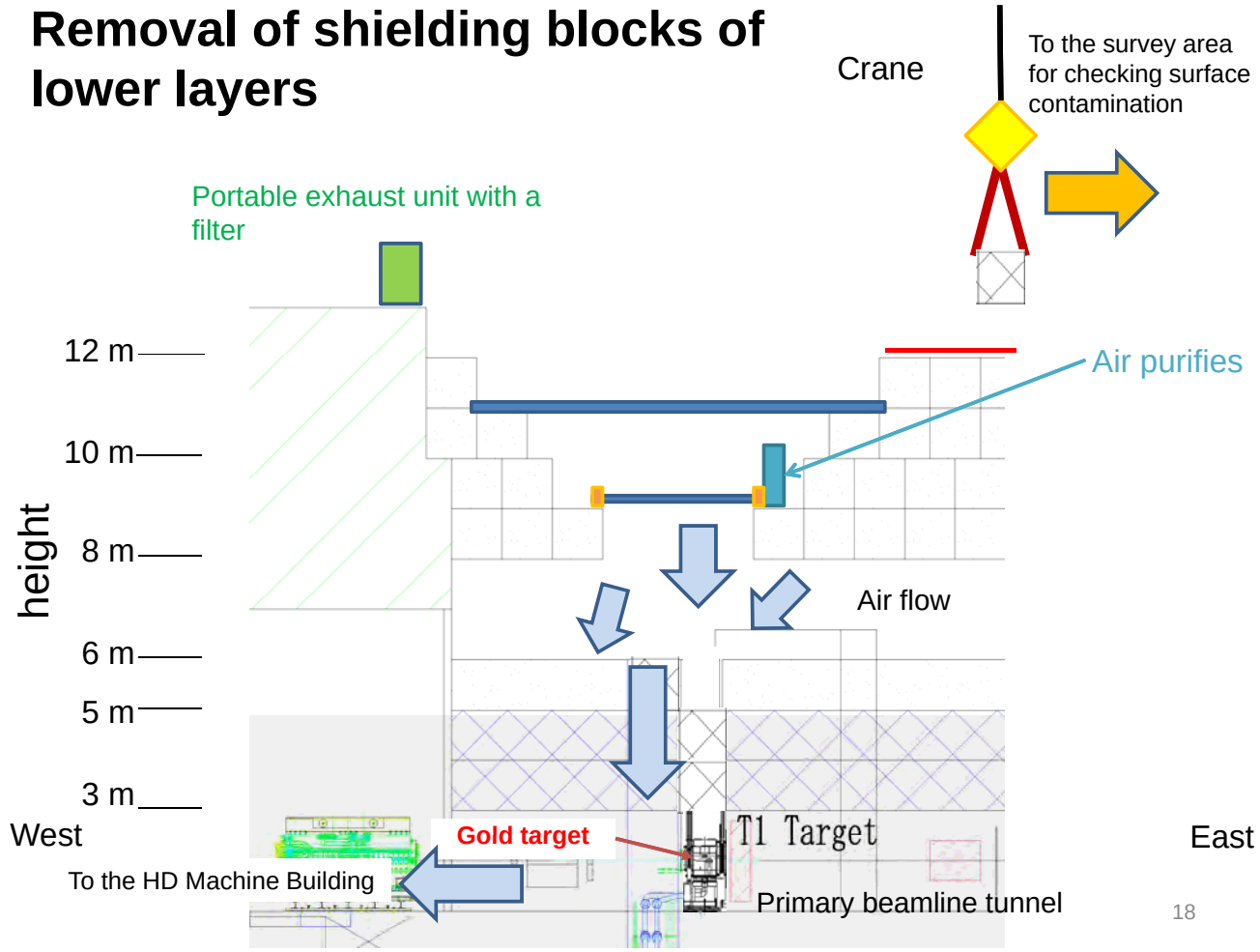
Air flow in the Hall while moving shielding blocks



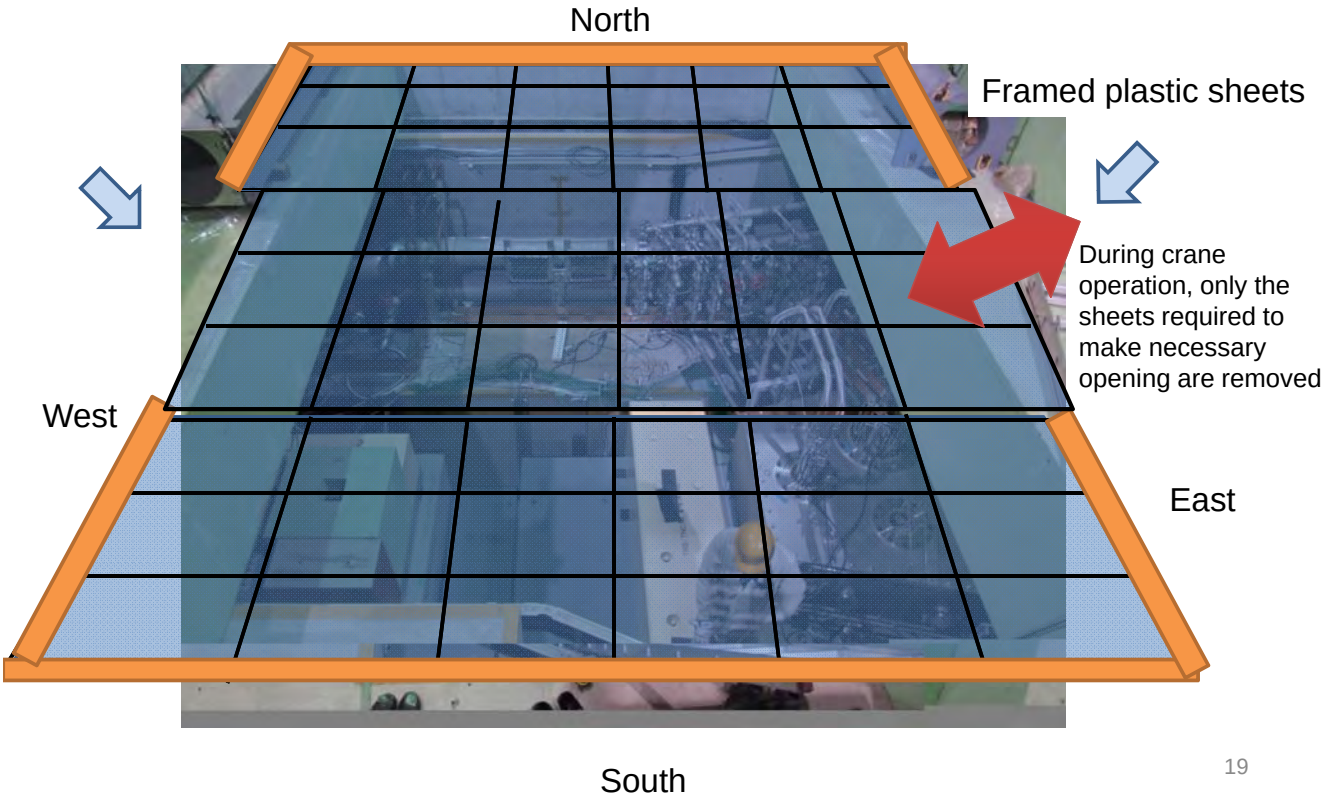
Removal of shielding blocks of lower layers



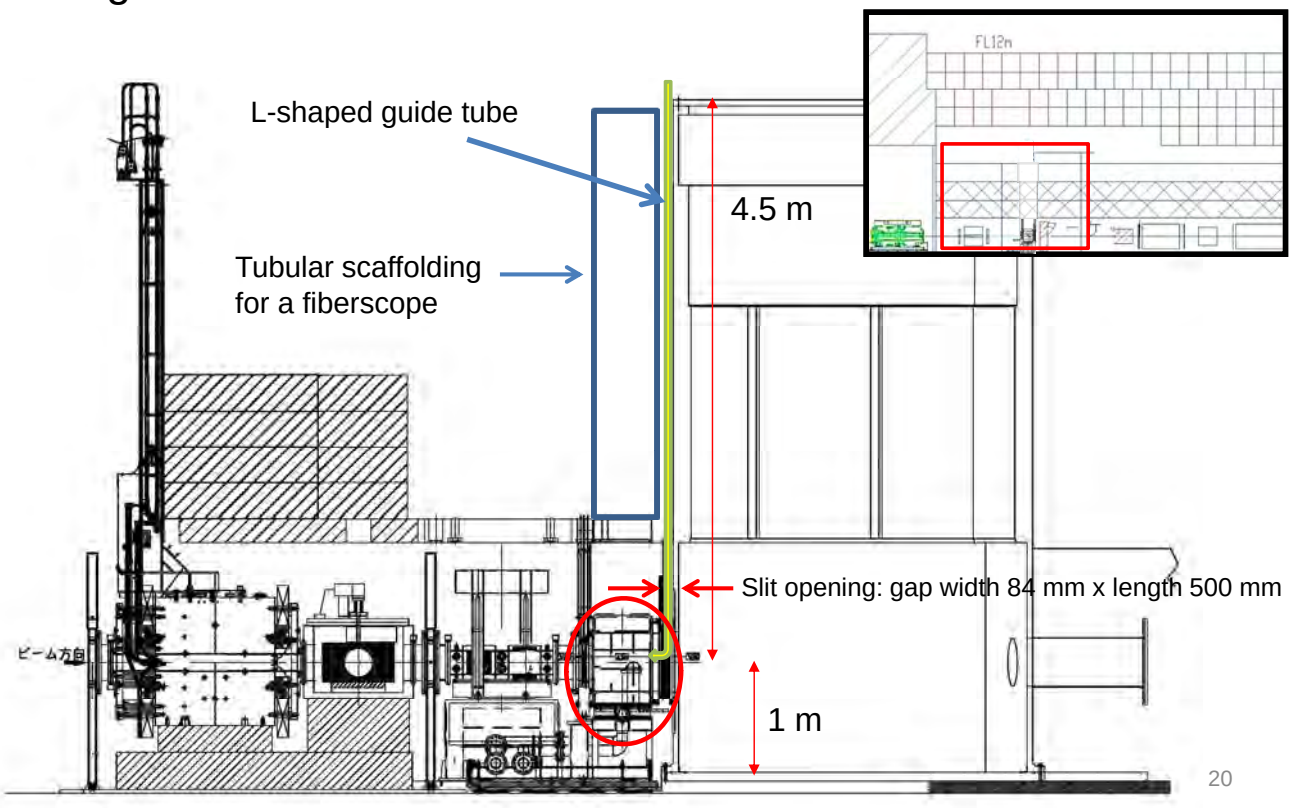
Removal of shielding blocks of lower layers

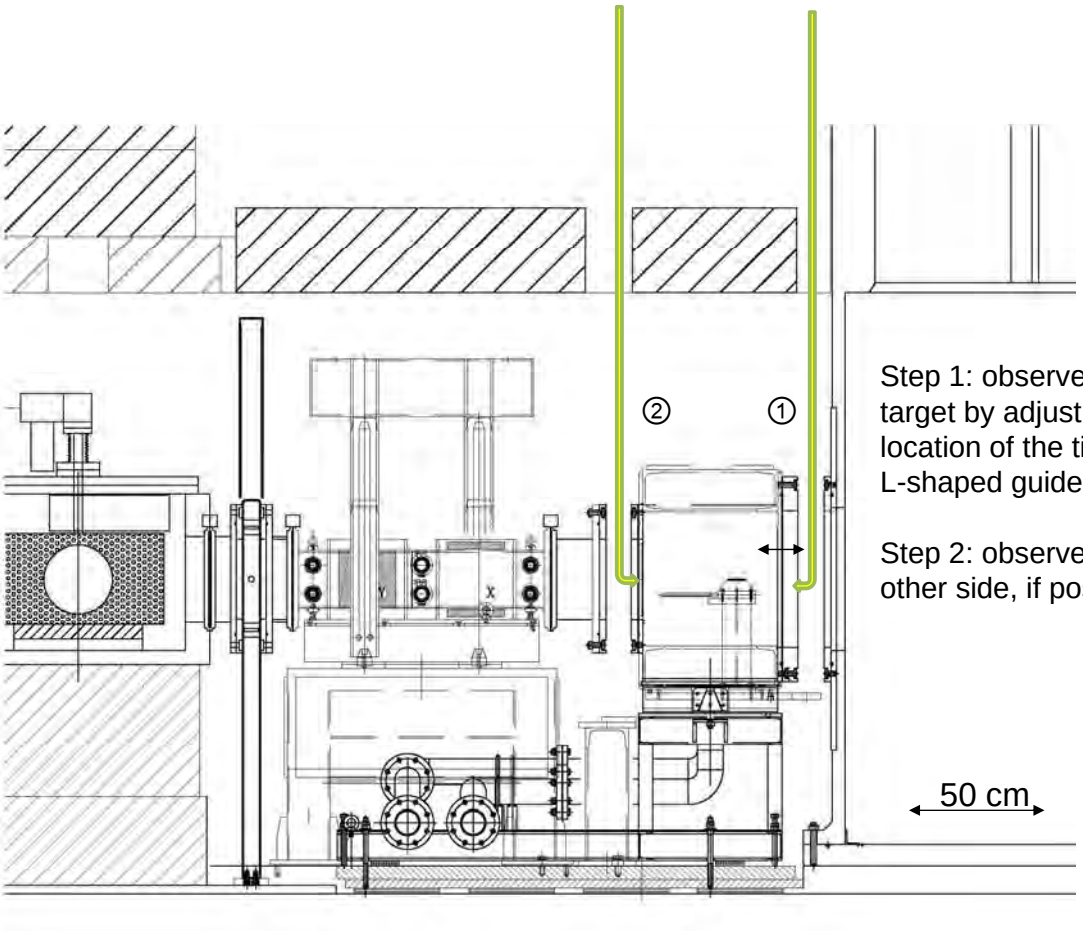


Temporary (shield) opening on the top of the gold target



When a suitable access path is prepared, the gold target is examined by using a fiberscope, etc. guided through an L-shaped tubing.





Step 1: observe the gold target by adjusting the location of the tip of the L-shaped guide

Step 2: observe from the other side, if possible.

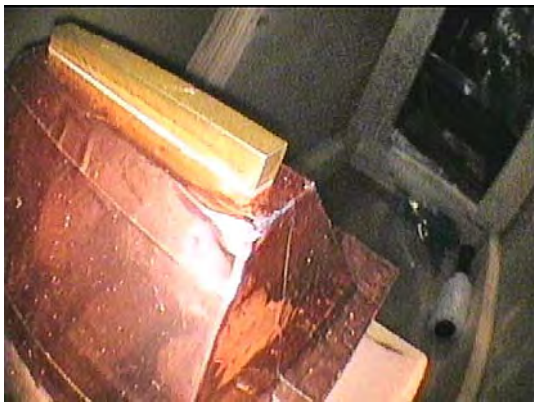
The fiberscope to be used

Practice run with a dummy target

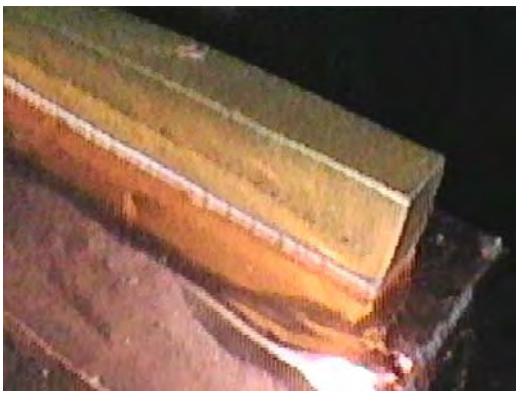
mock-up scaffolding (4.5 m high)

The dummy target and mock guide pipe

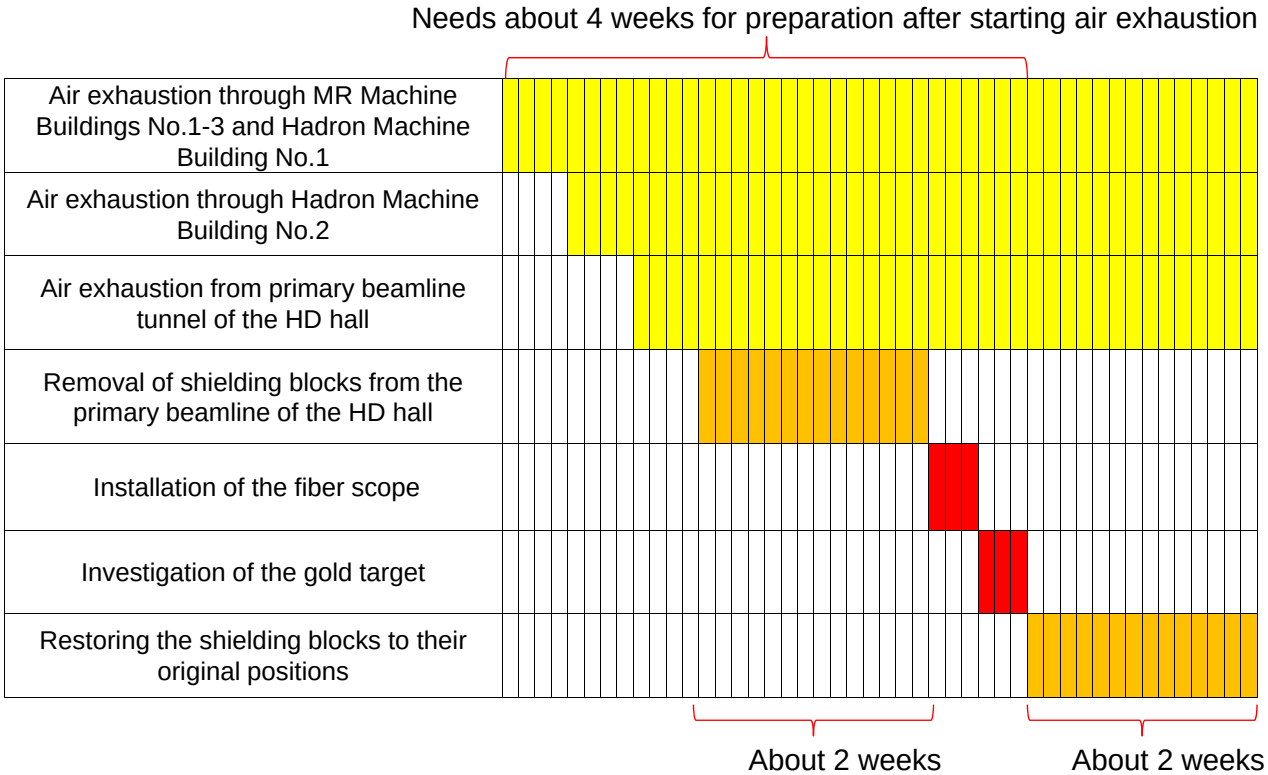
unlighted video scope image



up close image obtained with digital zooming



Schedule of Investigation of the Gold Target



Actual schedule may vary.