Safe handling III
(Actual RI handling)

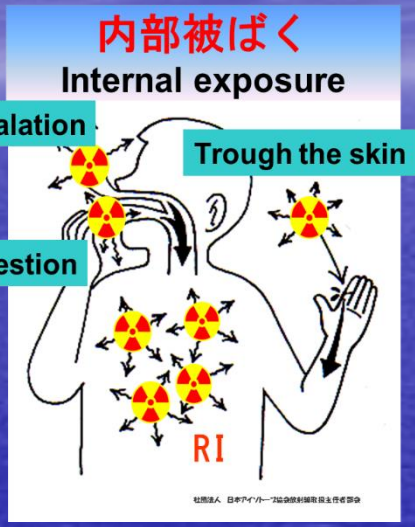
Rough classification of radioisotopes

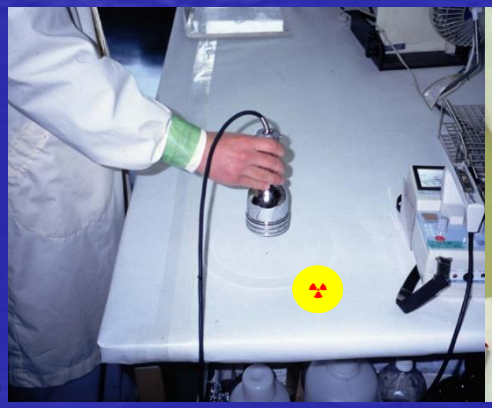
Sealed radioisotopes
(sealed source)

Unsealed radioisotopes
(unsealed source)

Outline

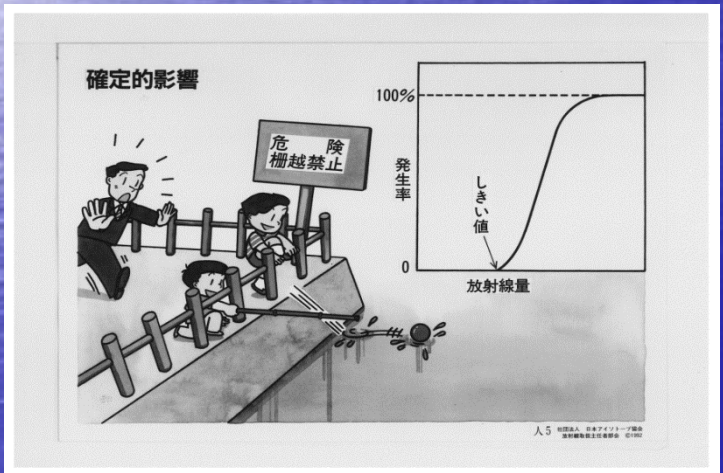
- The purpose of radiation protection
- External exposure protection
- Internal exposure protection
- Contamination protection
- How to handle radioisotopes in the work room

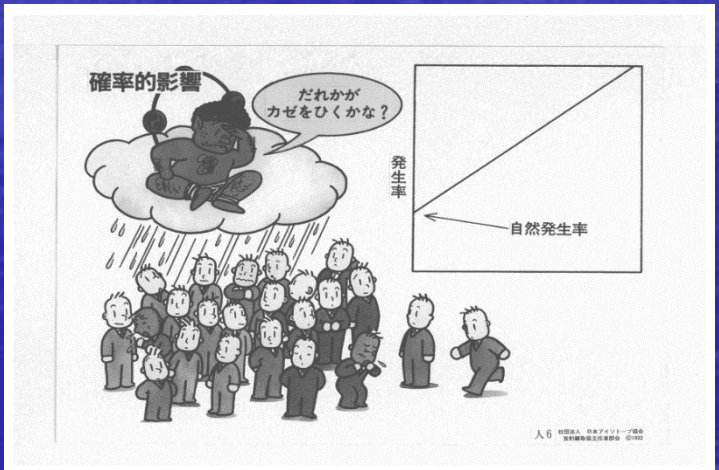




The purpose of radiation protection

- Preventing the occurrence of **deterministic effects** from radiation
  - Example: Lymphocyte depletion, hair loss
- Limit the occurrence of **stochastic effects** of radiation to acceptable levels
  - Example: Cancer incidence





- For whom?
  - Radiation users themselves and other radiation handlers
  - General public

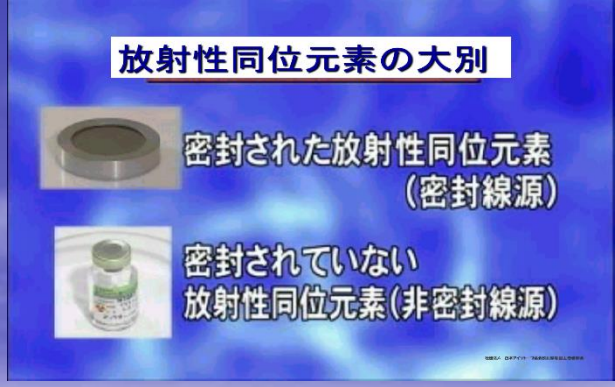
Concept of radiation protection

- Purpose and exposure restrictions
  - Justification of the act
    - Benefits brought by acts involving radiation exposure
      ＞Detriment caused by radiation exposure
    - Examination of alternative means without radiation exposure
  - Protective optimization
    - ALARA（as low as reasonably achievable）
      - Exposure doses, number of people exposed, and exposure opportunities must be kept as low as reasonably achievable, taking into account social and economic factors.
      - Dose limit

Concept of radiation protection

- 3 principles of safe handling
  - Contain：Limited use area
    - Controlled area
    - Use of the hood and glove box
    - Shield
  - Confine：bare minimum
    - Effectively use only the amount you need
  - Control：Radiation control
    - Used in a state where it can be properly managed and grasped

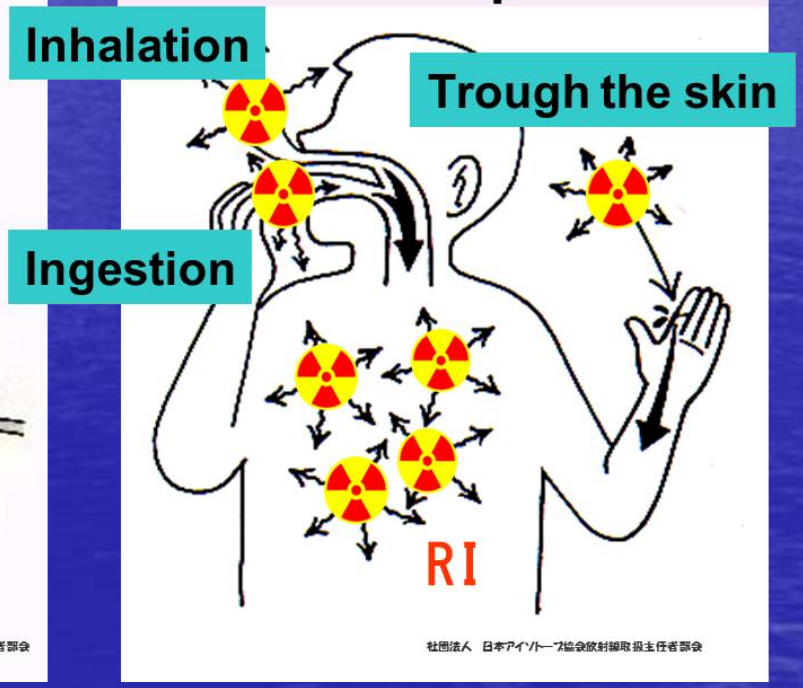
Radiation exposure



External exposure

Gamma rays, β rays, X-rays and highly radioactive sealed / unsealed RIs become a problem.

Internal exposure



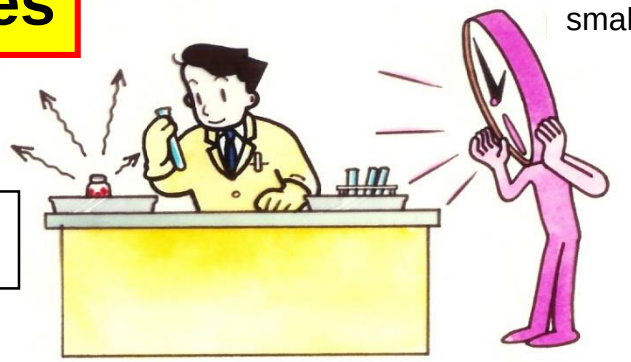
Invasion through the mouth, nose and wounds becomes a problem.

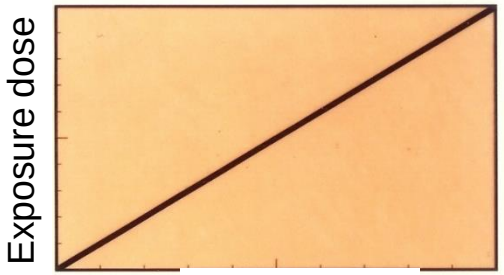
Principles of Protection from External Exposure

3 principles

Time

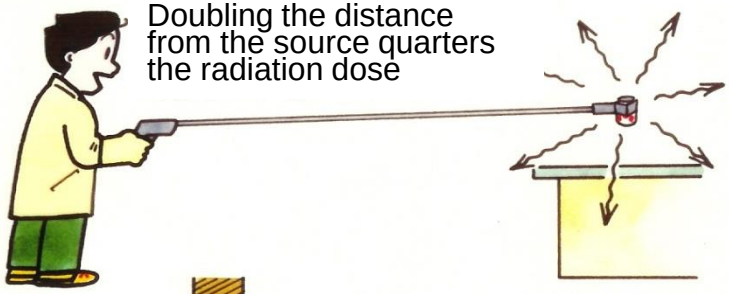
The shorter the time, the smaller the dose

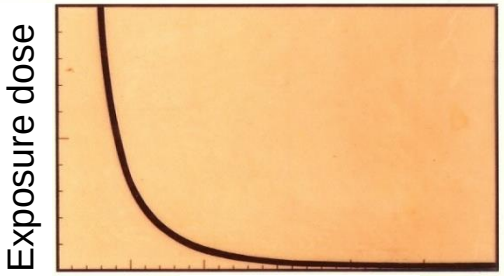




Distance

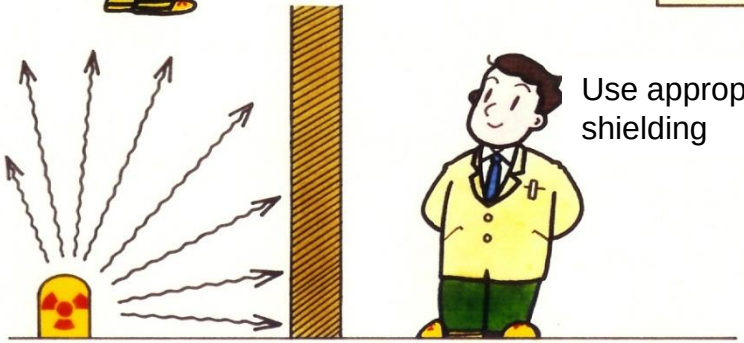
Doubling the distance from the source quarters the radiation dose

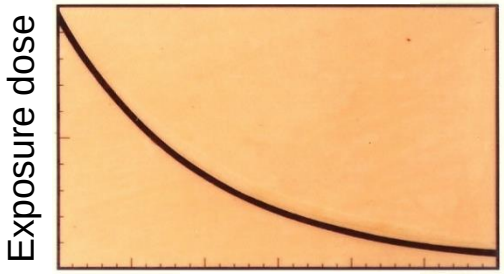




Shielding

Use appropriate shielding





大学等放射線施設協議会

Time

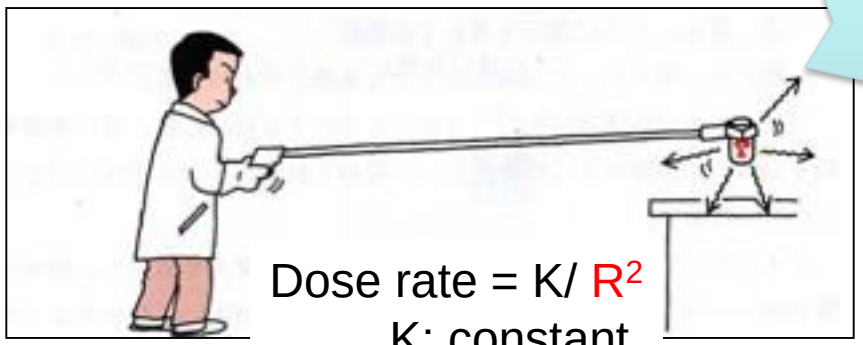
Keep exposure time short

Radiation dose increases in proportion to time.

- Make the working time as short as possible!
- Do a “Cold run” practice and understand the individual steps of each procedure.

Distance

Stay as far away as possible



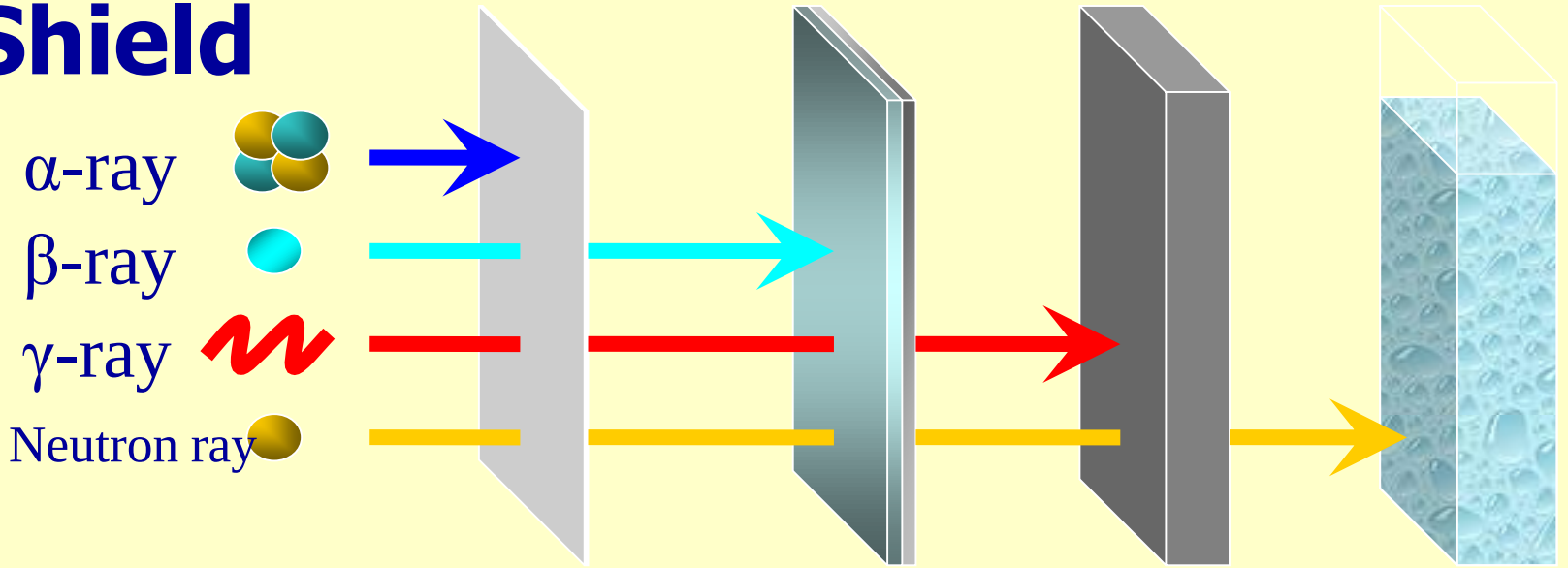
Dose rate = K/ R^2

K: constant

R: distance

- The radiation dose decreases in inverse proportion to the square of the distance from the radiation source.
  - Keep as much distance between yourself and the radiation source as possible!
  - Don’t touch the radiation source directly.
  - Use remote handling equipment such as tongs or forceps.

Shield



α-ray : Heavy particles with positive electricity. It stops after flying a few centimeters in the air.

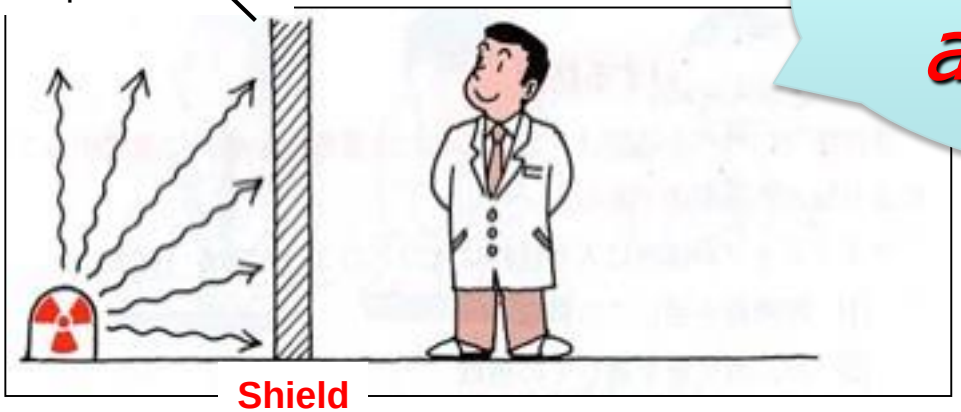
β-ray : Light particles (electrons) with negative electricity. It stops after flying a few meters in the air.

γ-ray : Electromagnetic waves. Attenuates with lead plate and concrete.

Neutron ray : Particles without electricity. Attenuates with concrete and water.

Shielding

As near to the radiation source as possible



Protect with a shield

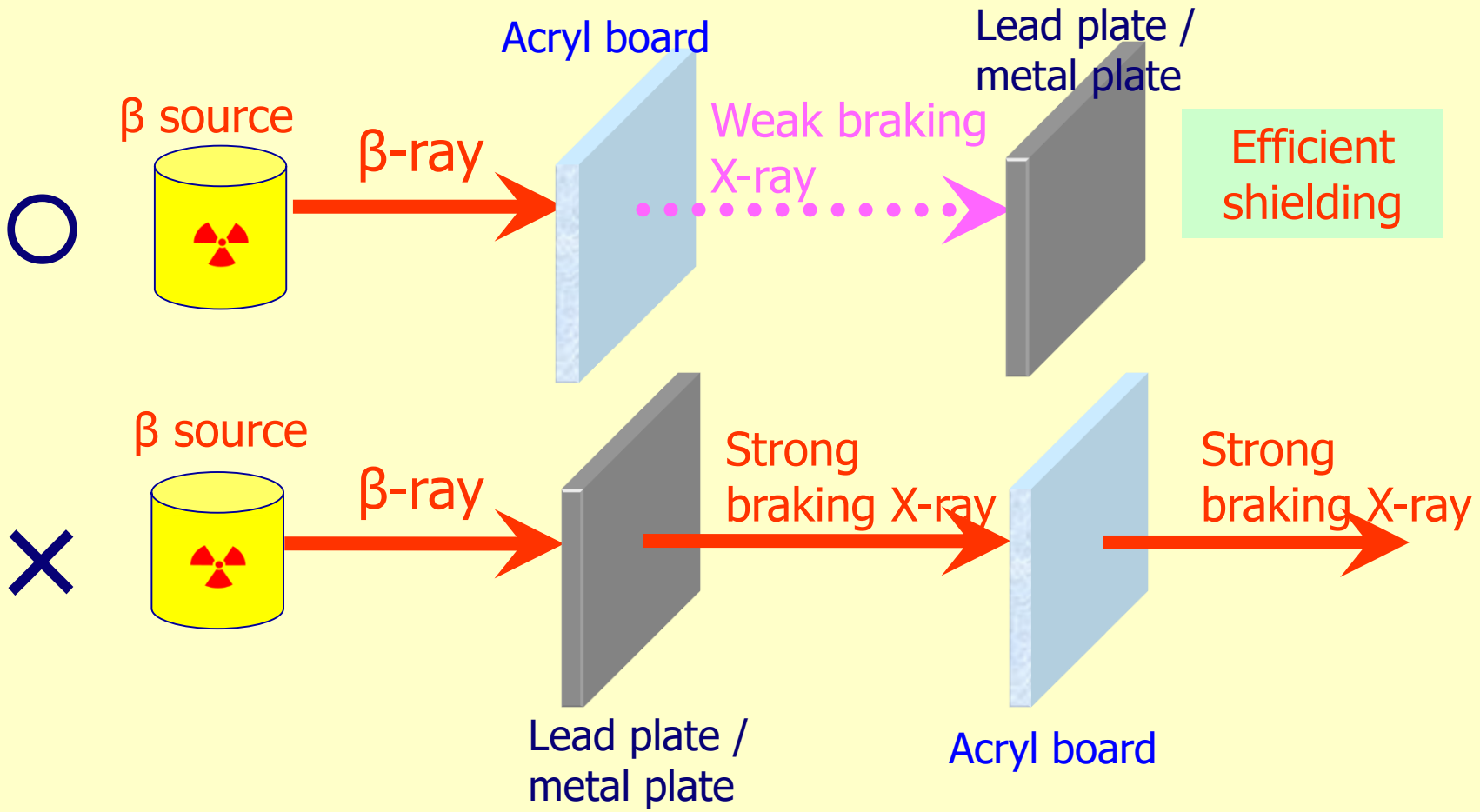
You can protect yourself from radiation exposure by shielding the radiation source.

Radiation type	Shielding material
β -ray	aluminum board (several mm) plastic acryl board (several cm)
γ -ray	lead block, iron block, concrete block
neutron	block containing boron, water

β-ray shielding

(be careful of Bremsstrahlung)

The higher atomic number, the stronger Bremsstrahlung are generated.



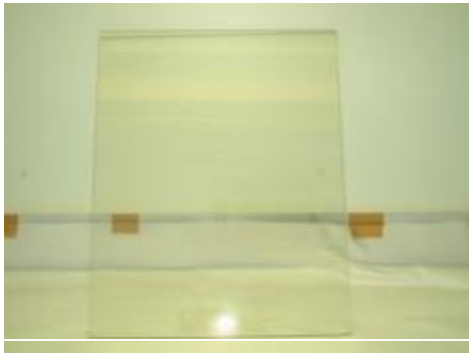
Shielding

Shielding of **β-ray**

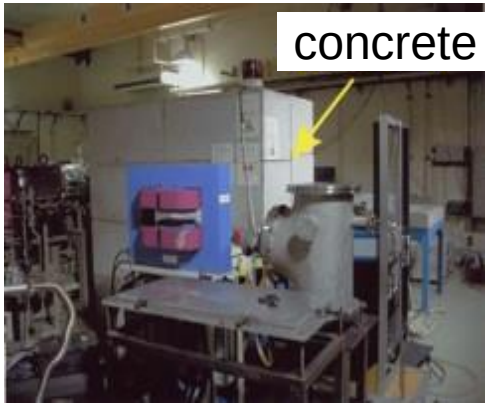
Plastic or acryl board

Shielding of **γ-ray**

lead block



lead glass
(glass board containing lead)

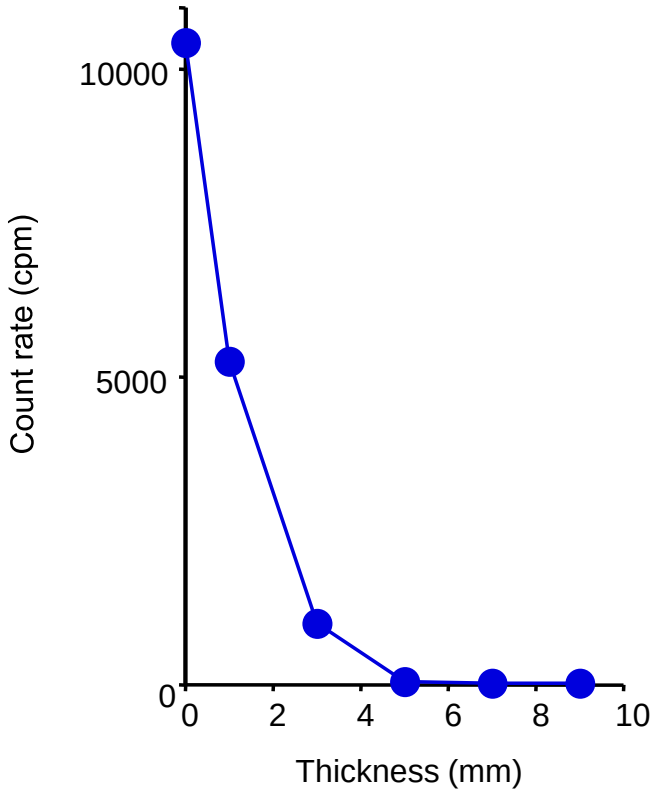


Shielding for β-ray (^{32}P, 5kBq)

Equipment

Result

Thickness of acrilate (mm)	Count rate (cpm)	Count rate - background
0	10448	10424
1	5248	5224
3	1011	987
5	60	36
7	34	10
9	33	9
Background	24	0

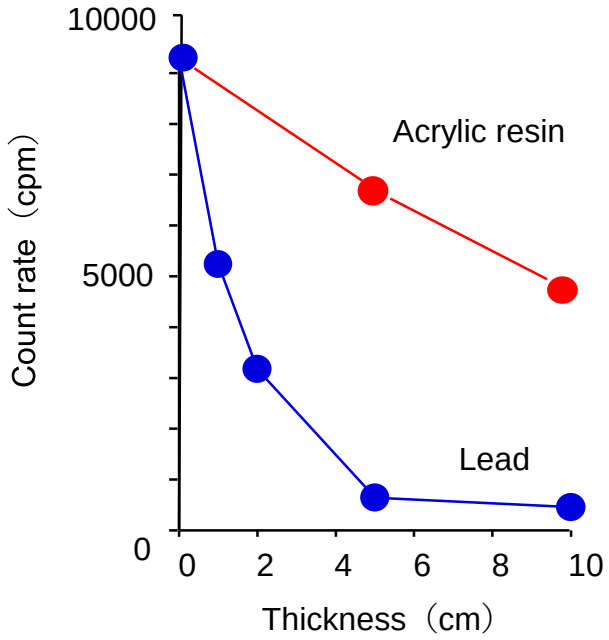


Shielding for γ-ray (^{60}Co, 37MBq)

Equipment

Result

Thickness of shielding (cm)	Lead (cpm)	Acrylate (cpm)
0	9271	9271
1	5226	
2	3142	
5	630	7089
7		
9		
10	424	4553



Effective done：E （μSv・h^{-1}）

$$E = \frac{\Gamma_E \times A}{r^2}$$

Effective done constant：Γ_E （μSv・m^2・MBq^{-1}・h^{-1}）

Ex：^{60}Co：0.305　　^{99m}Tc：0.0181

^{131}I：0.0545　　^{137}Cs：0.0779

Radioactivity of the source：A （MBq）、

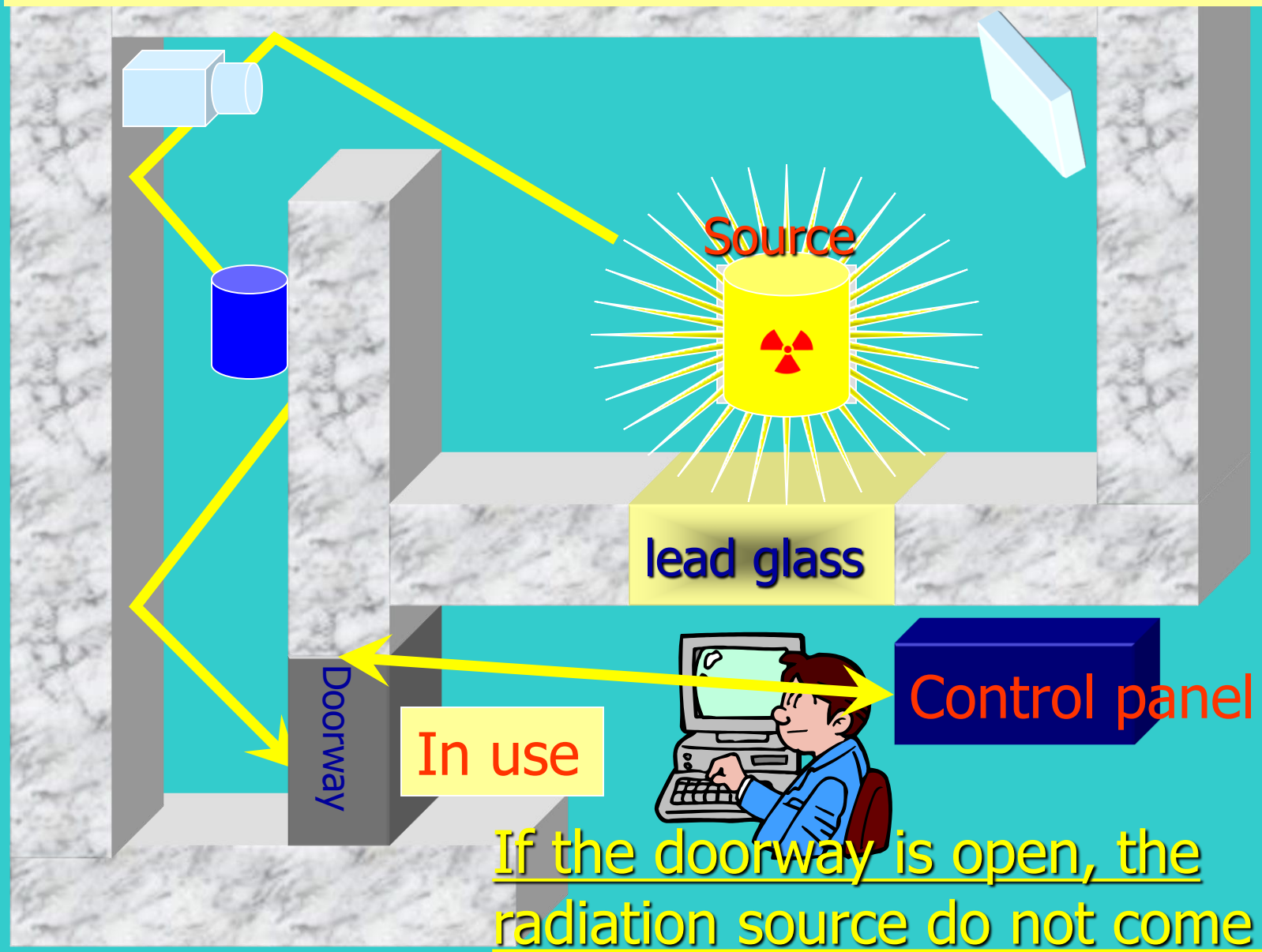
Distance from the source：r （m）

Confirm safety before experiment

Example: Using 60Co (Γ_E: 0.305) 10MBq at a distance of 0.5m for 100 hours a year .. Estimated to be approximately 1220μSv / year.

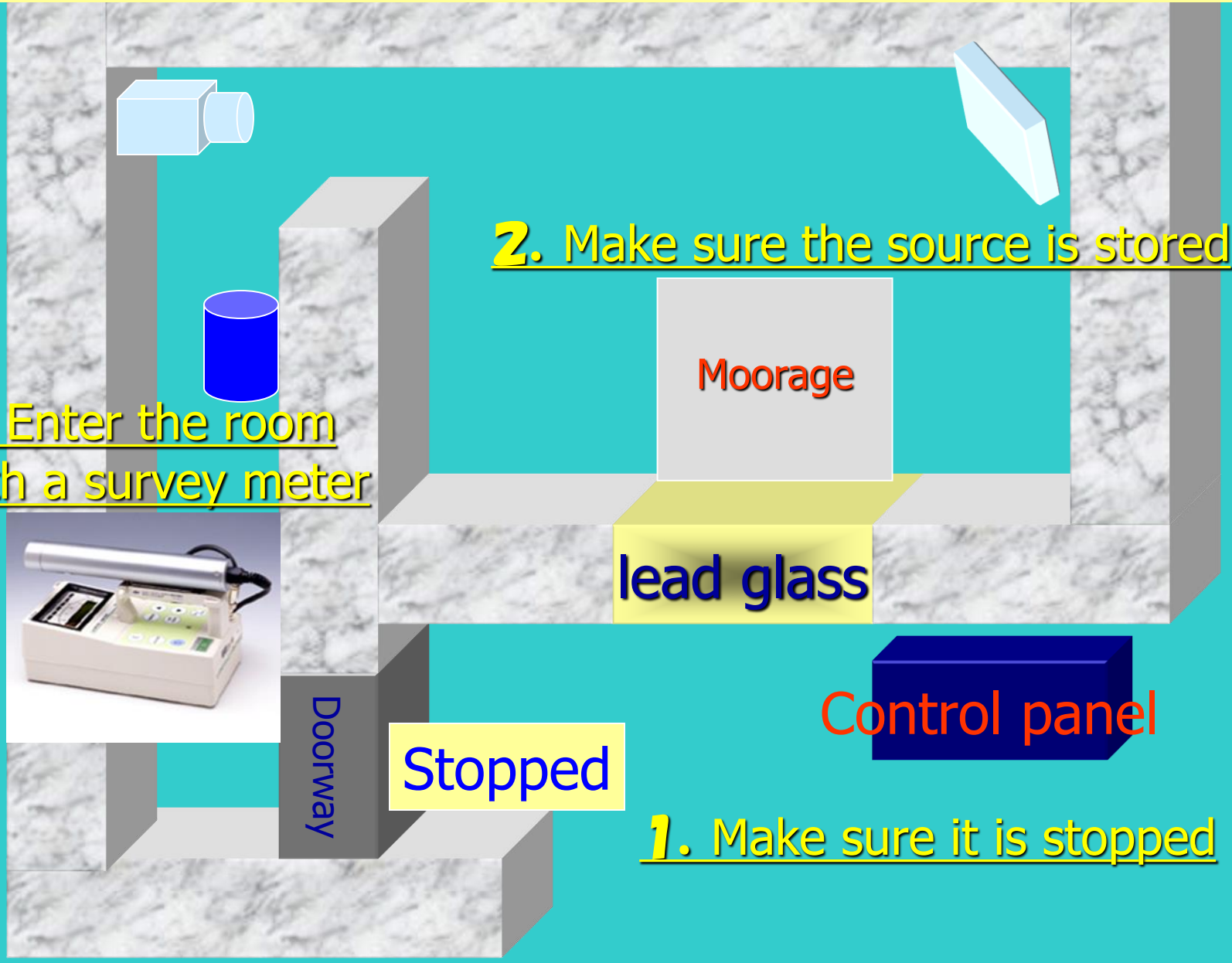
Use a shield (lead, etc.) to reduce the exposure dose.
If it is necessary to reduce it further, adjust the usage amount, time, and distance.

Sealed radiation source irradiation facility, automatic display device, interlock

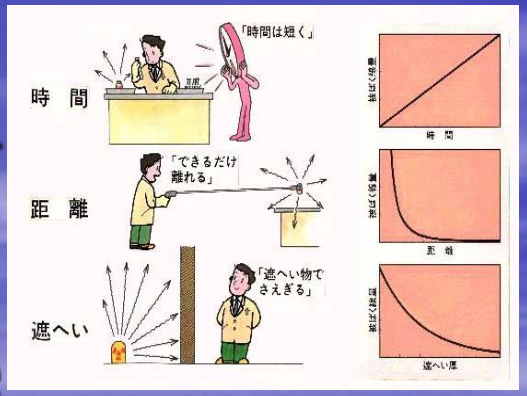


If the doorway is open, the radiation source do not come out.

Precautions when entering the irradiation area



Points for safety handling



Sealed ***RI***

- Considered only external exposure
  - Time, Distance, Shield

- (Small sealed)
  - Lost
  - Damaged coating

- (Irradiation facility)
  - Safety confirmation before driving (no people in the irradiation room)
  - Safety confirmation after stop (radioactive source is stored)

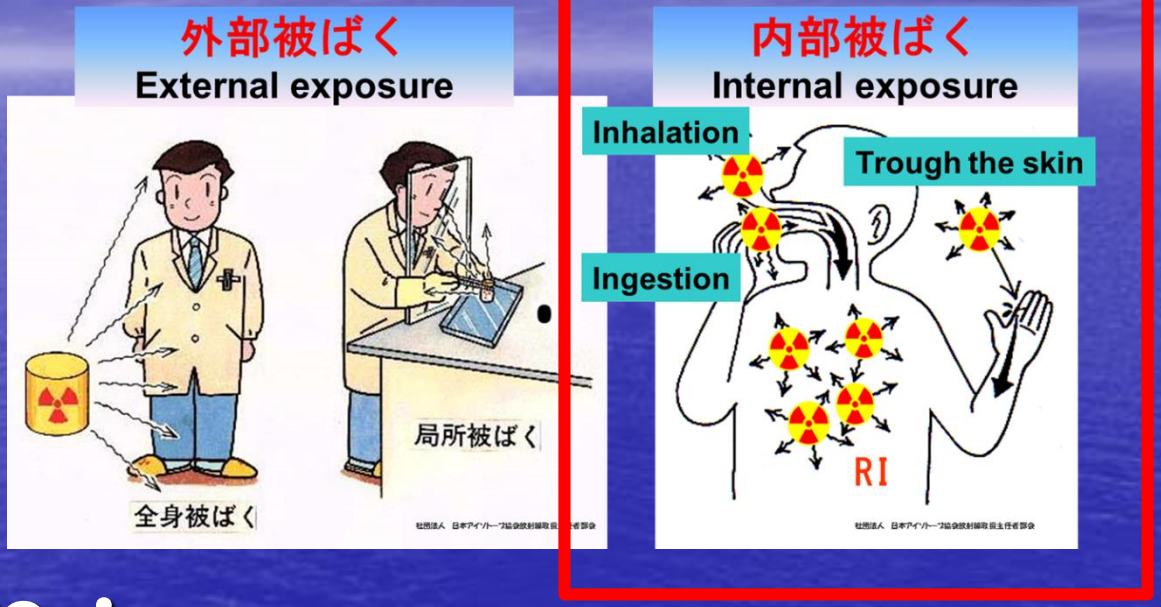
Points for safe handling

Sealed ***RI***(Irradiation facility)

- Do not overconfident in safety devices such as interlocks and area monitors.
  - Accidents due to safety device failures are also possible.
  - Remember the location of the switch that opens the door, the intercom, and the emergency stop button!
  - Bring a survey meter or pocket dosimeter with an alarm when entering the room

Points for safe handling

Unsealed ***RI***



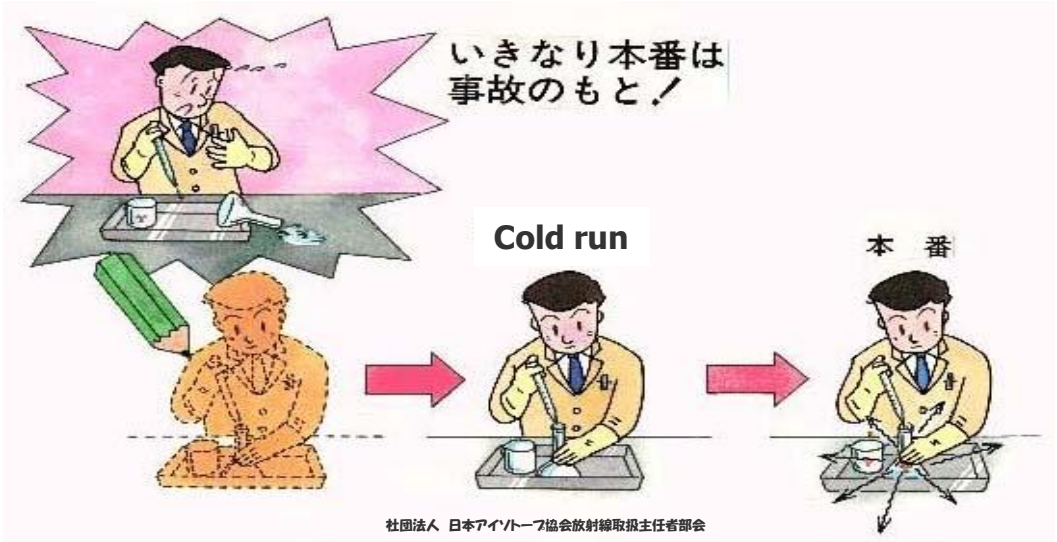
Pay attention to ：

- External exposure
- Internal exposure
- contamination

Plan and Preparation

- First to know
  - Necessity of using RI
  - Use of less dangerous nuclides
  - Confirmation of the amount required for the experiment
  - Estimation of exposure dose

Consider in advance what kind of danger (exposure, contamination, etc.) exists from the nature of RI (energy, line type, etc.), amount used, and experimental content.



Rehearsal before RI experiment

- Prepare necessary items
  - Clean up unnecessary items
- Preliminary experiment without using RI (Cold run)
  - Reconfirmation of procedures, mastery of work
- Take measures
  - Accident prevention measures, efficient work
- Production
  - Reduction of work time
  - Reduction of exposure

Prevention of internal exposure

- Prevention of inhalation
  - Operate the exhaust equipment and handle it in the hood
  - Do not place your head in the hood
  - Wear a mask.
  - No smoking
- Prevention of ingestion
  - Use of safety pipettor and dispenser.
  - Prohibition of eating and drinking.
- Prevention of skin ingestion
  - Prevents skin exposure.
    - Wear the prescribed lab coat.
    - Wear gloves. (Pinhole check)
    - Check for trauma ⇒ Prohibition of work

Protection against Internal Exposure

Unsealed radioisotopes can enter into the body through the following three intake routes

Inhalation

Through the respiratory system

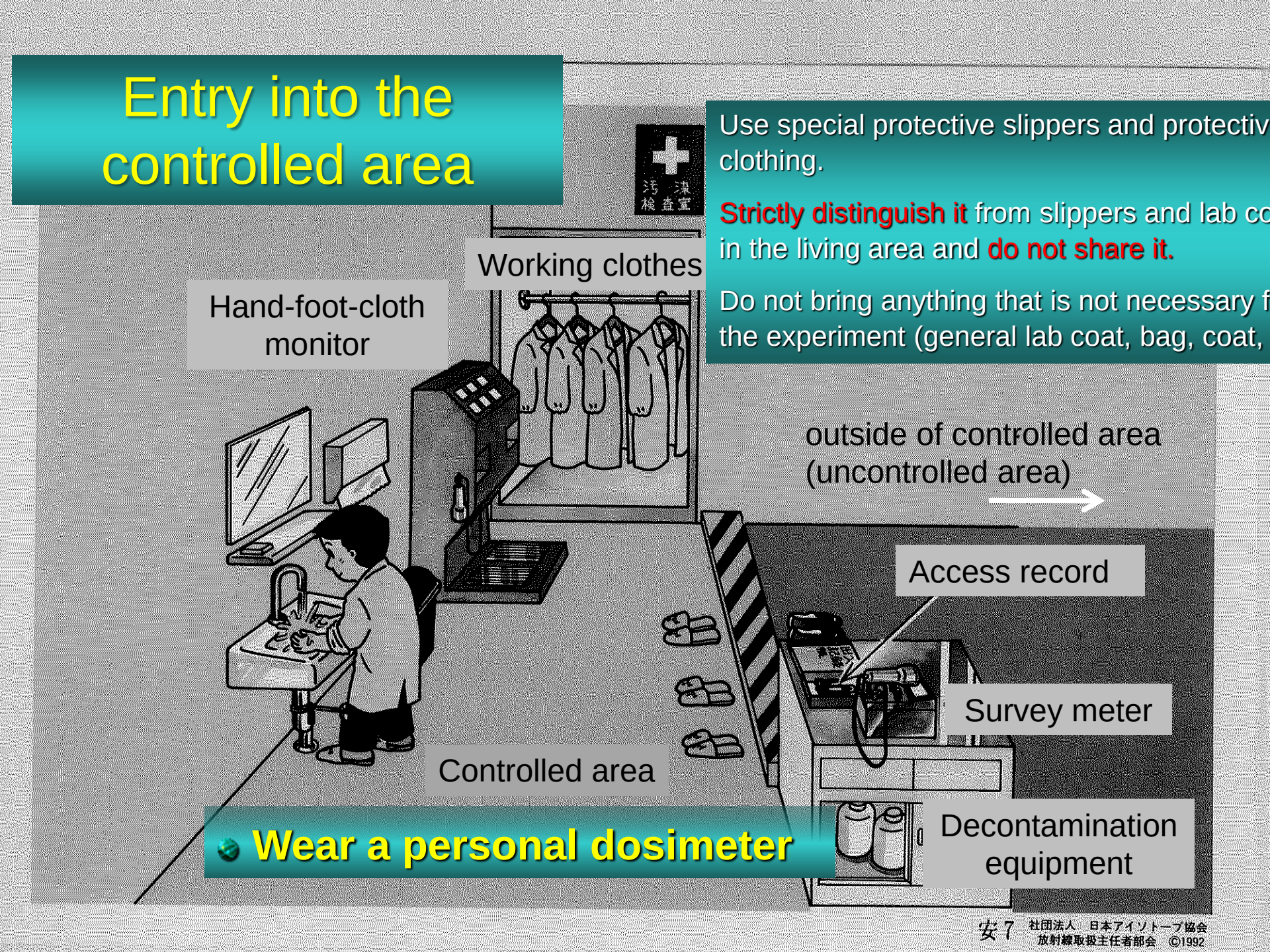
Ingestion

Through the digestive system

Percutaneous uptake

Through the skin, especially a wound

Entry into the controlled area



Use special protective slippers and protectiv clothing.

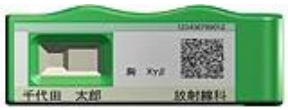
Strictly distinguish it from slippers and lab co in the living area and do not share it.

Do not bring anything that is not necessary f the experiment (general lab coat, bag, coat,

- **Wear a personal dosimeter**

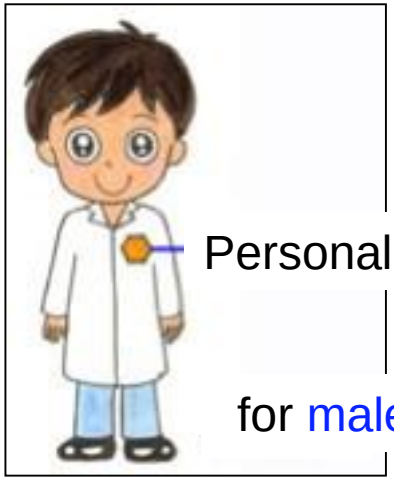
Personal dosimeters

Luxel badge



Glass badge

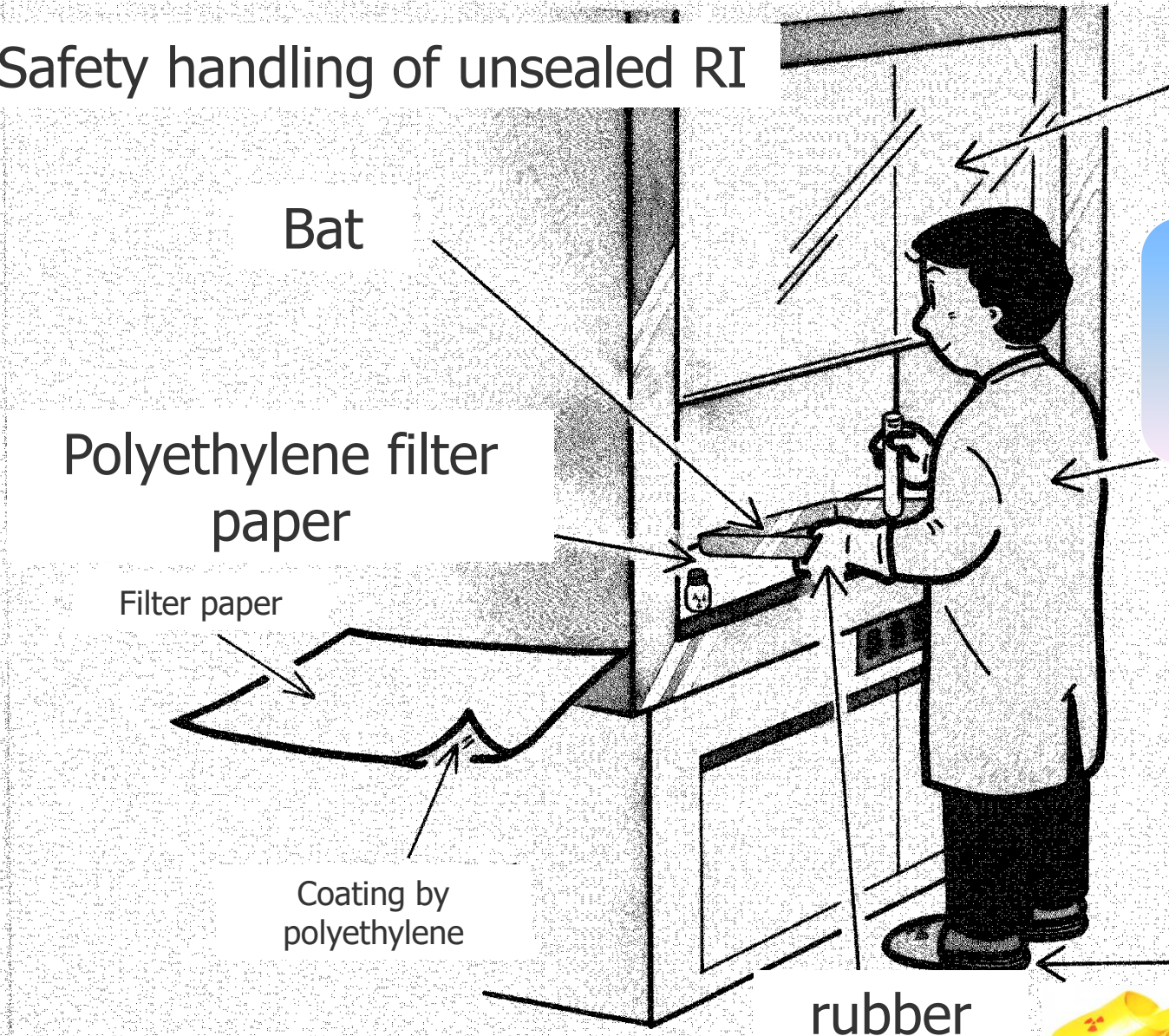
Pocket dosimeter



Put on the chest for males

Put on the abdomen for females

Safety handling of unsealed RI



Draft

Bat

Polyethylene filter paper

Filter paper

Coating by polyethylene

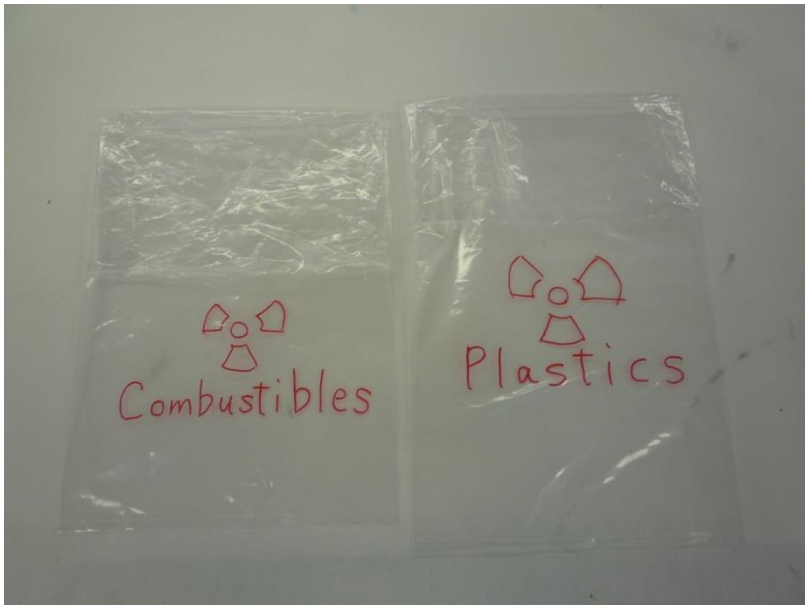
Prevent the experimen from inhaling RI contaminated air

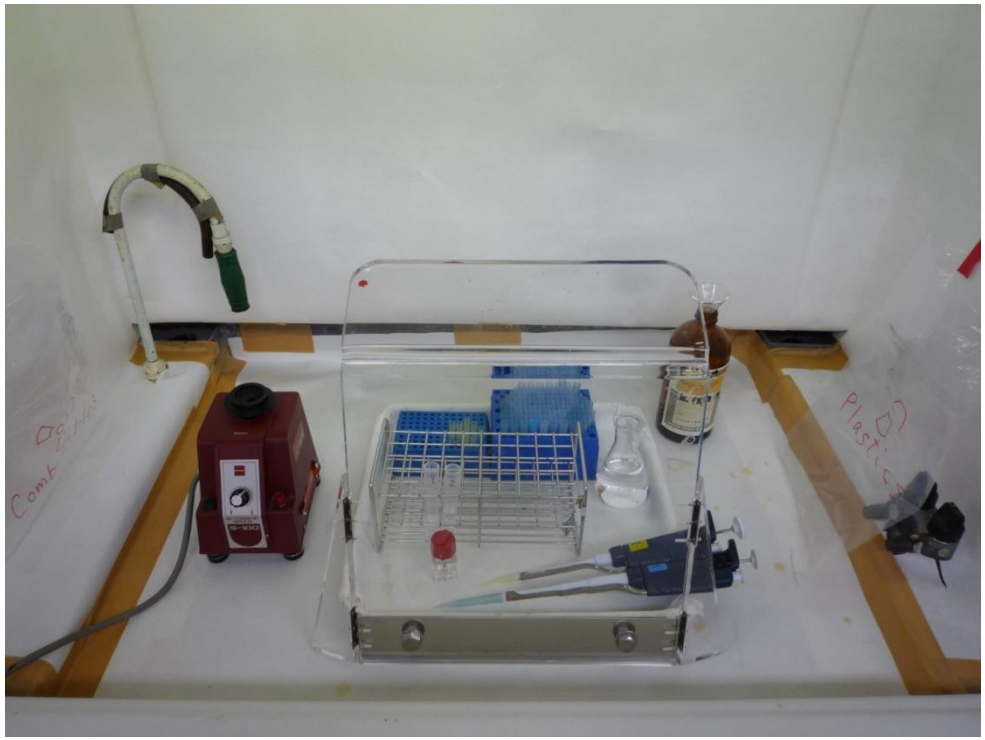
Do not expose the sk

Dedicated slippe

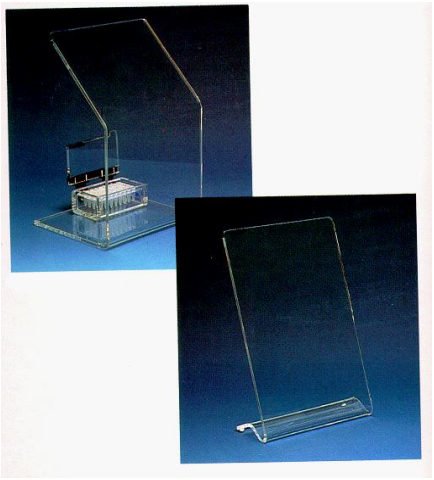
rubber glove

Place the protection shield, the wrapped tray and the plastic bags for radioactive wastes in the hood.

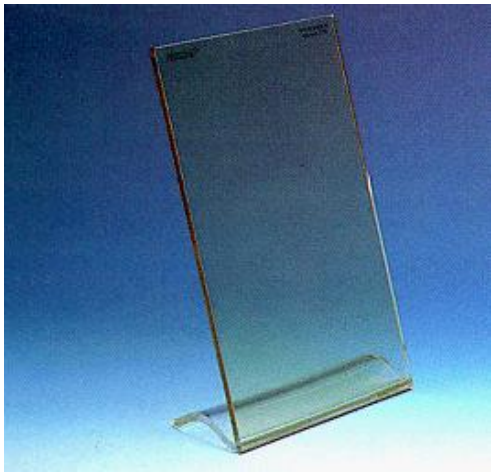




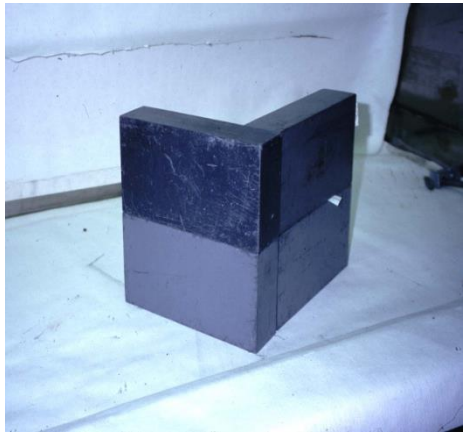
Protective equipment for external radiation



Acryl board



Acryl board containing Lead



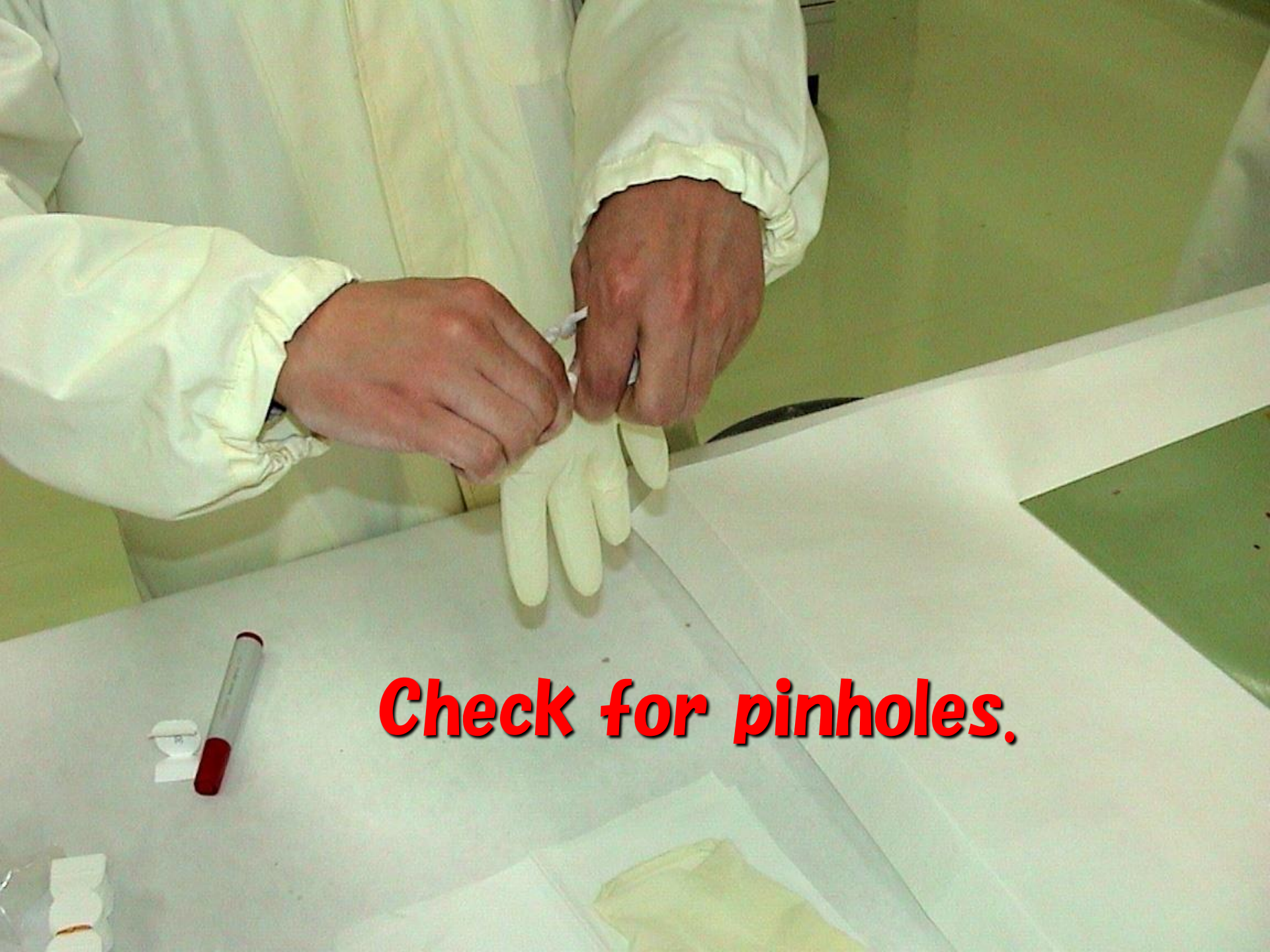
Lead brock

Working clothes containing Lead

Exposure protection

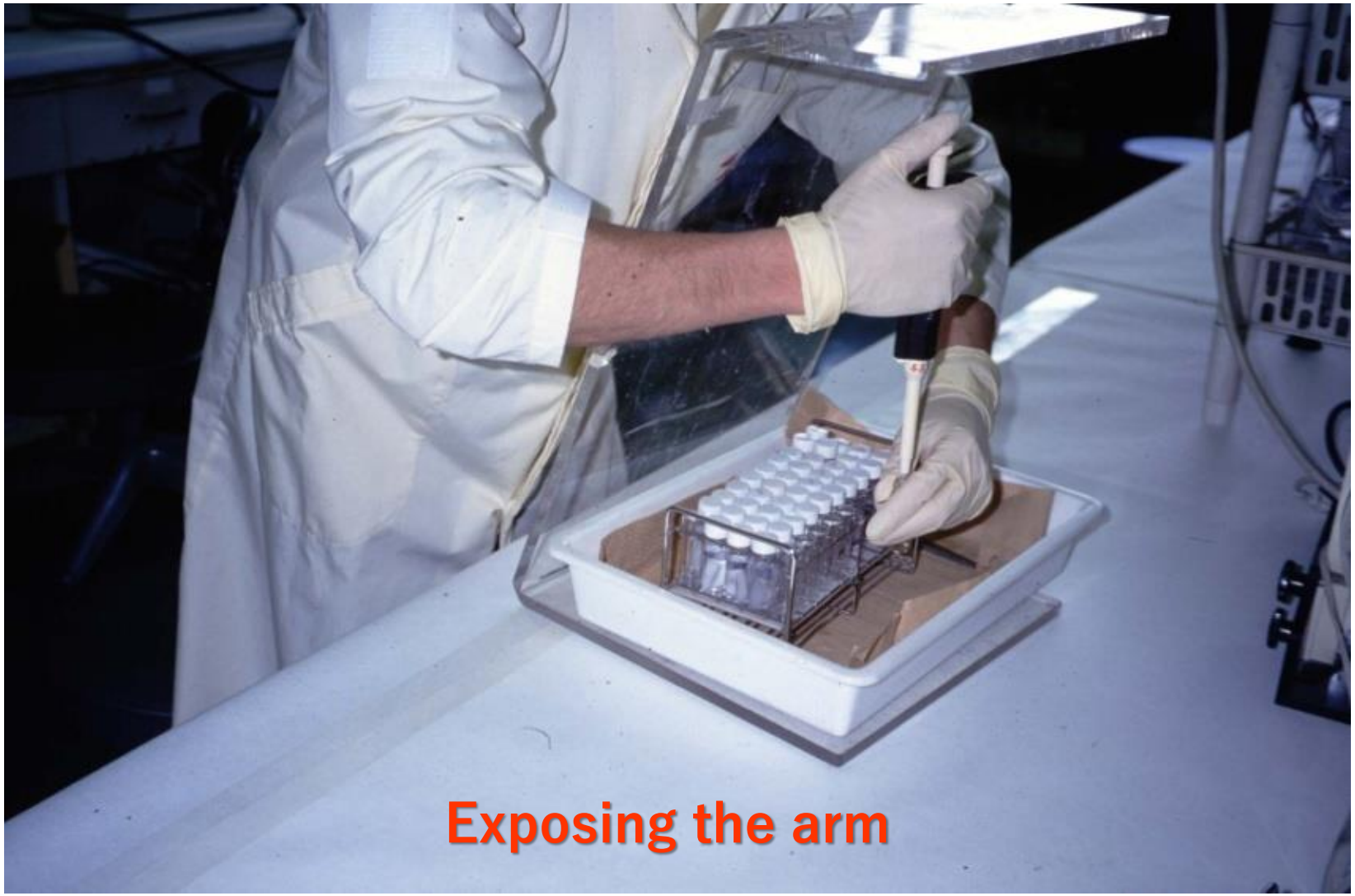
Exposure protection

Ex)Exposure reduction method for other radiation handlers


Check for pinholes.

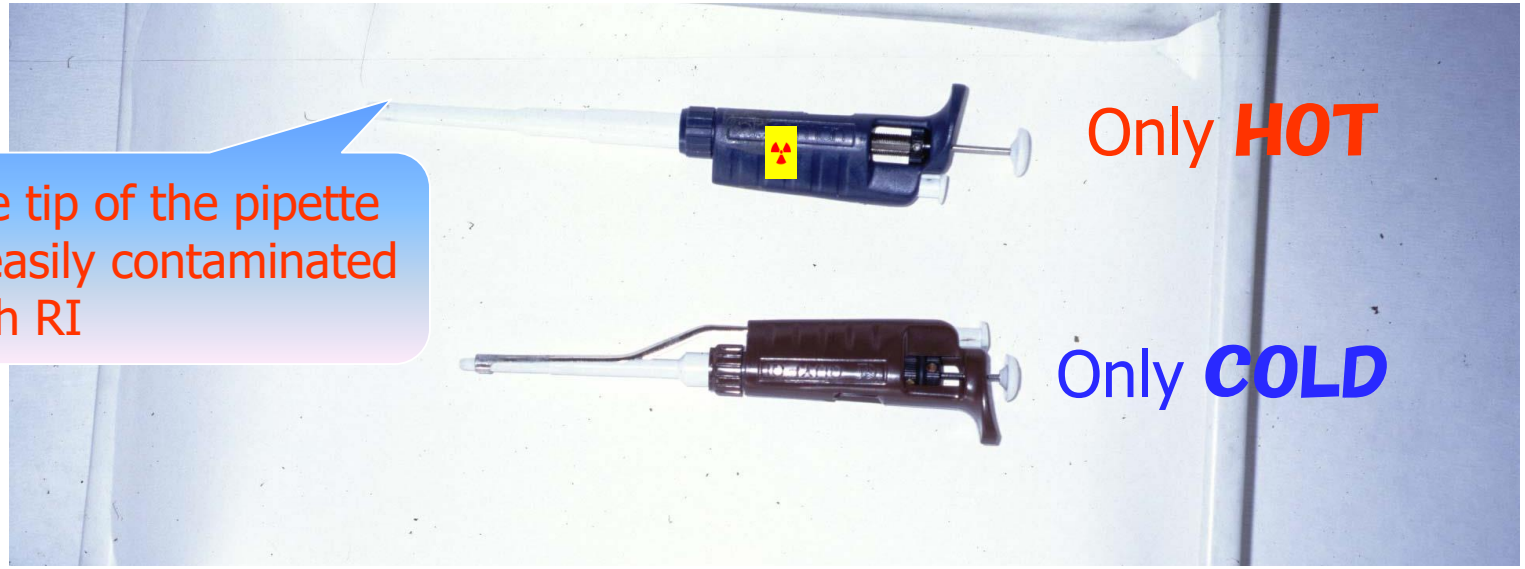

Correct example
Hang the cuff strap on your thumb.
Put gloves on the cuffs.

Bad example



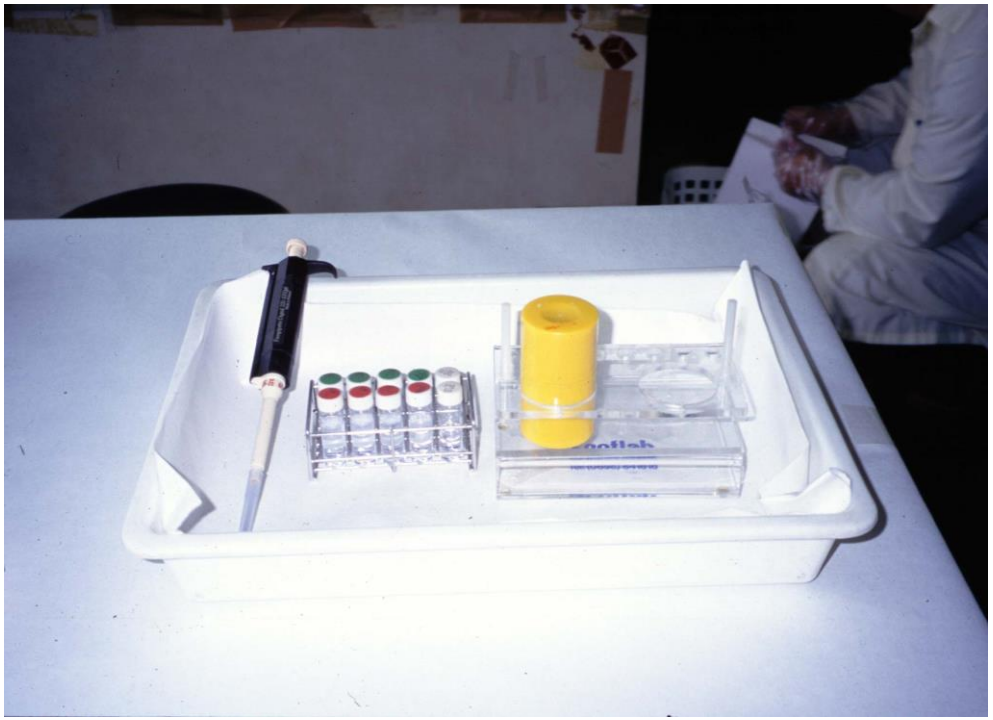
Exposing the arm

Measures against contamination



Proper use of pollution pipettor and non-contamination pipettor

Measures against contamination



Limit places and things to be contaminated

Easy to handle when contaminated!

Measures against contamination

use a tray

use a cart

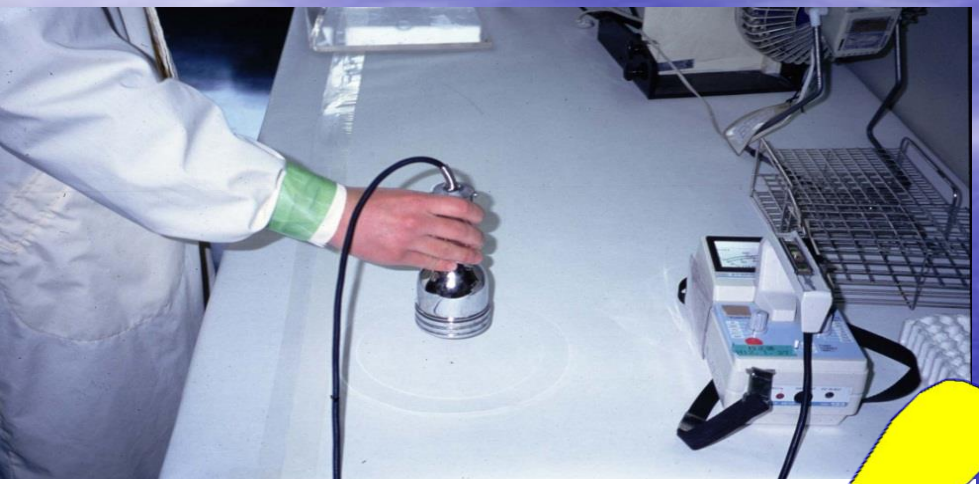
use a bucket

To avoid accidents, use of a tray, a cart and a bucket is recommended.

The surface of a tray and a cart should be covered with polyethylene-coated paper sheets.

Measures against contamination

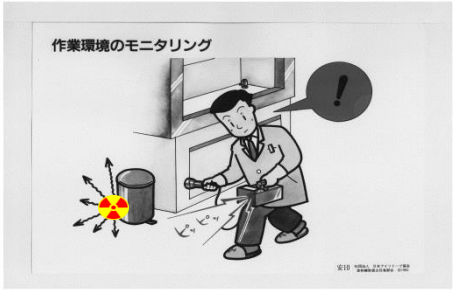
(Measurement of the place used for the experiment)



Handling with bare hand

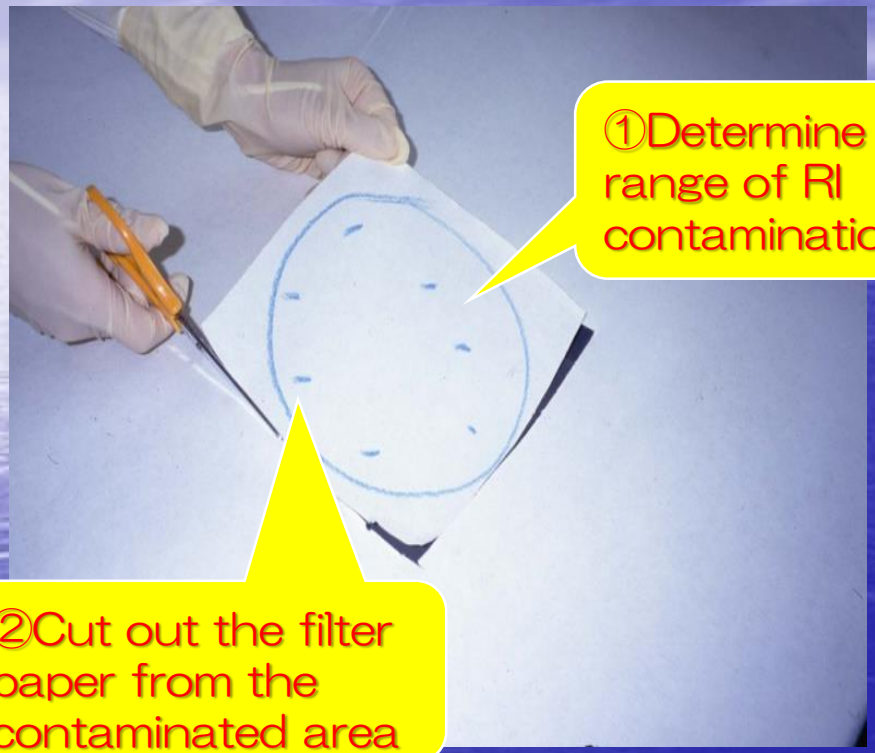
Handling while wearing gloves

- Check the work area for contamination before and after use.
- Hands, work clothes, equipment, utensils, drafts, workbenches, floors, sinks for RI, and their vicinity inspected for contamination at each work break.
- If the slippers are contaminated, the entire room will be contaminated.

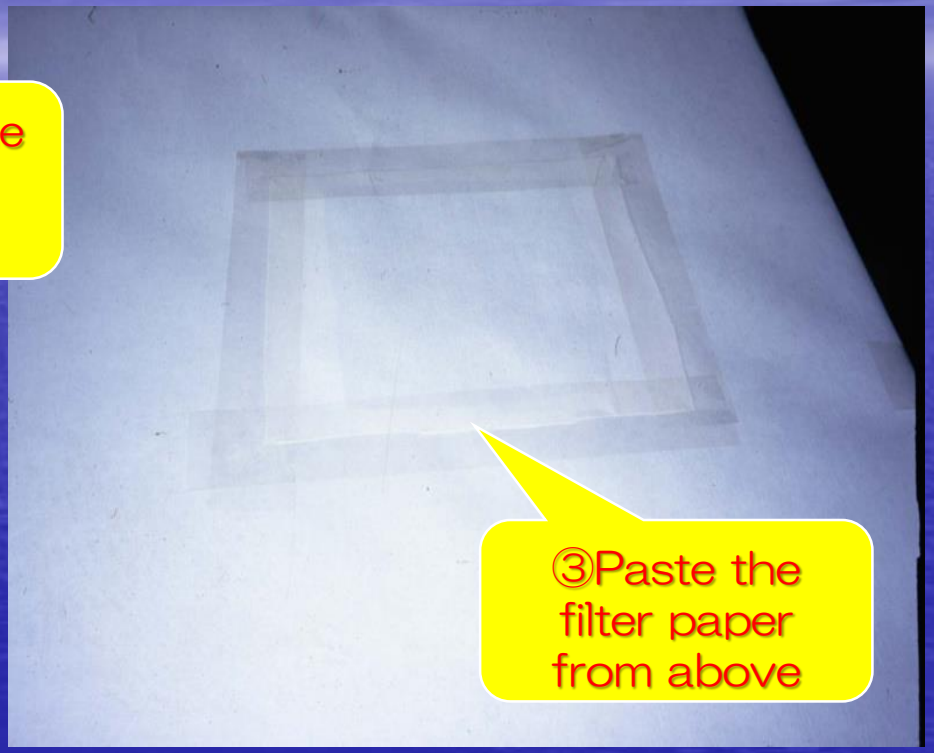


Measures against contamination

(Treatment when contamination is found)



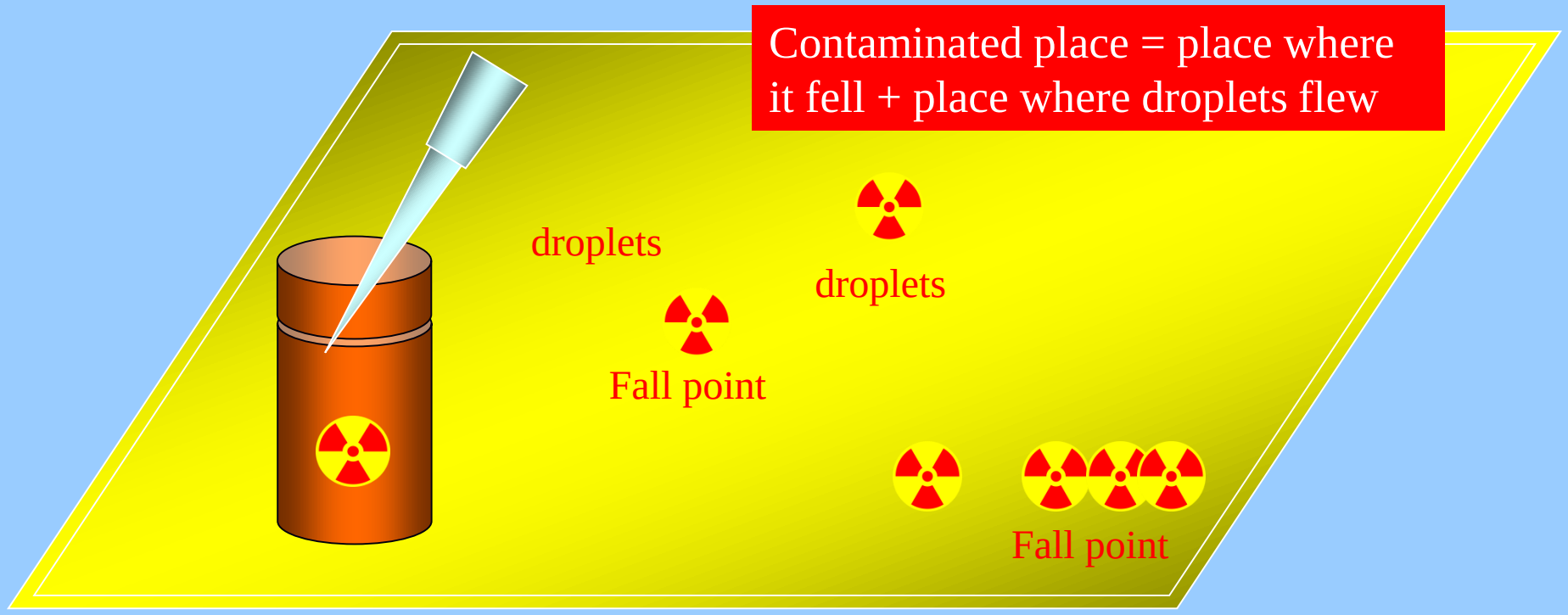
Cutting out contaminated filter paper



Repair of cutouts

Places where pollution is likely to occur

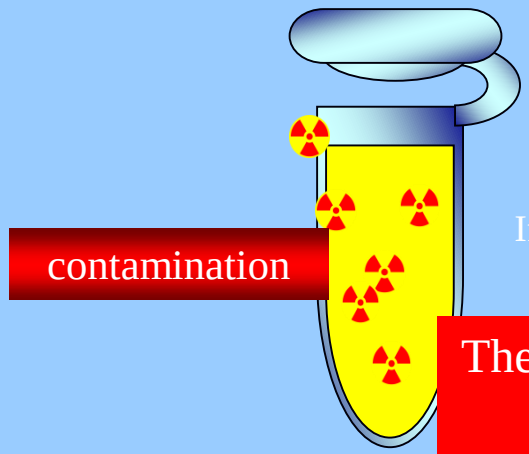
- When I took the RI out of the source container, I dropped the tip of the micropipetter.
- I dropped the plastic instrument containing the RI solution.



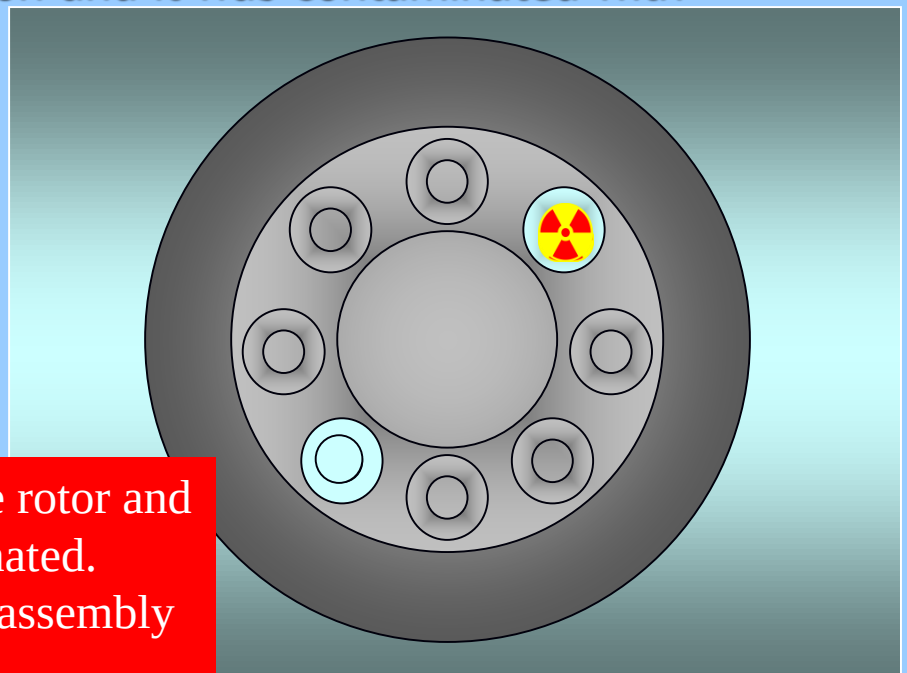
参考資料：RIの逆襲（秀潤社）

Places where pollution is likely to occur

- I centrifuged the microtubes without noticing that they were contaminated.
  - When inserting RI into the microtube with a pipettor, the tip of the tip touched the lid.
  - The lid became contaminated as the cap was repeatedly opened and closed.
  - There was too much internal solution and it was contaminated with pressure when the cap was closed.



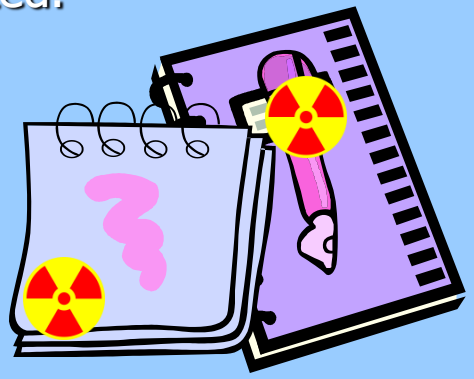
If you centrifuge it while it is contaminated ...

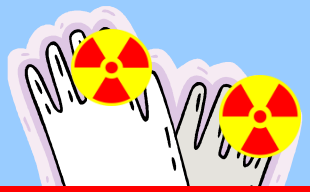


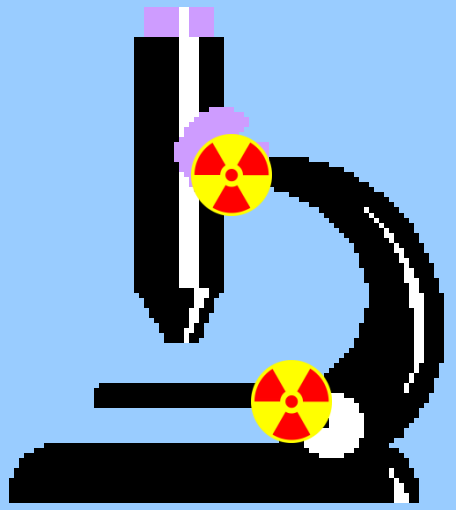
The entire inner wall of the rotor and centrifuge is contaminated. Decontamination after disassembly is required

Places where pollution is likely to occur

- No hoods or drafts were used when dealing with highly volatile RIs.
- I handled my lab notebook and lab equipment without noticing that my gloves were contaminated.







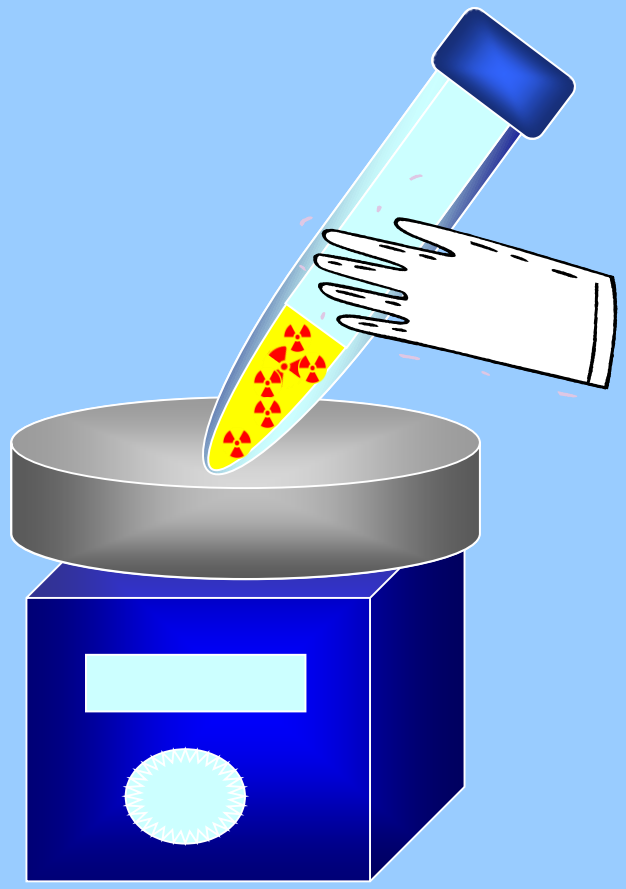
Do not touch anything that should not be contaminated with gloves on. Check gloves for contamination after each work and replace them immediately if they may be contaminated.

参考資料：RIの逆襲（秀潤社）

Places where pollution is likely to occur

- When stirring the solution with a vortex mixer, cover it while holding the center of the test tube so that the solution does not rise to the top of the test tube.

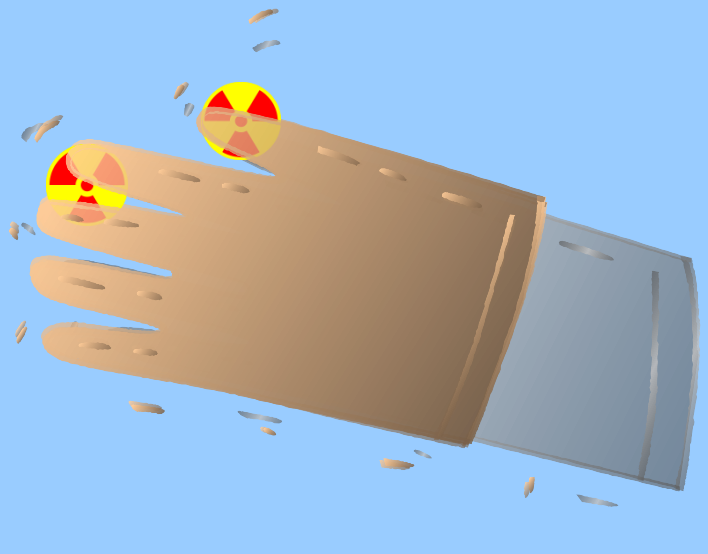
* If you hold the upper side, the liquid will rise and the lid will be contaminated.



参考資料：RIの逆襲（秀潤社）

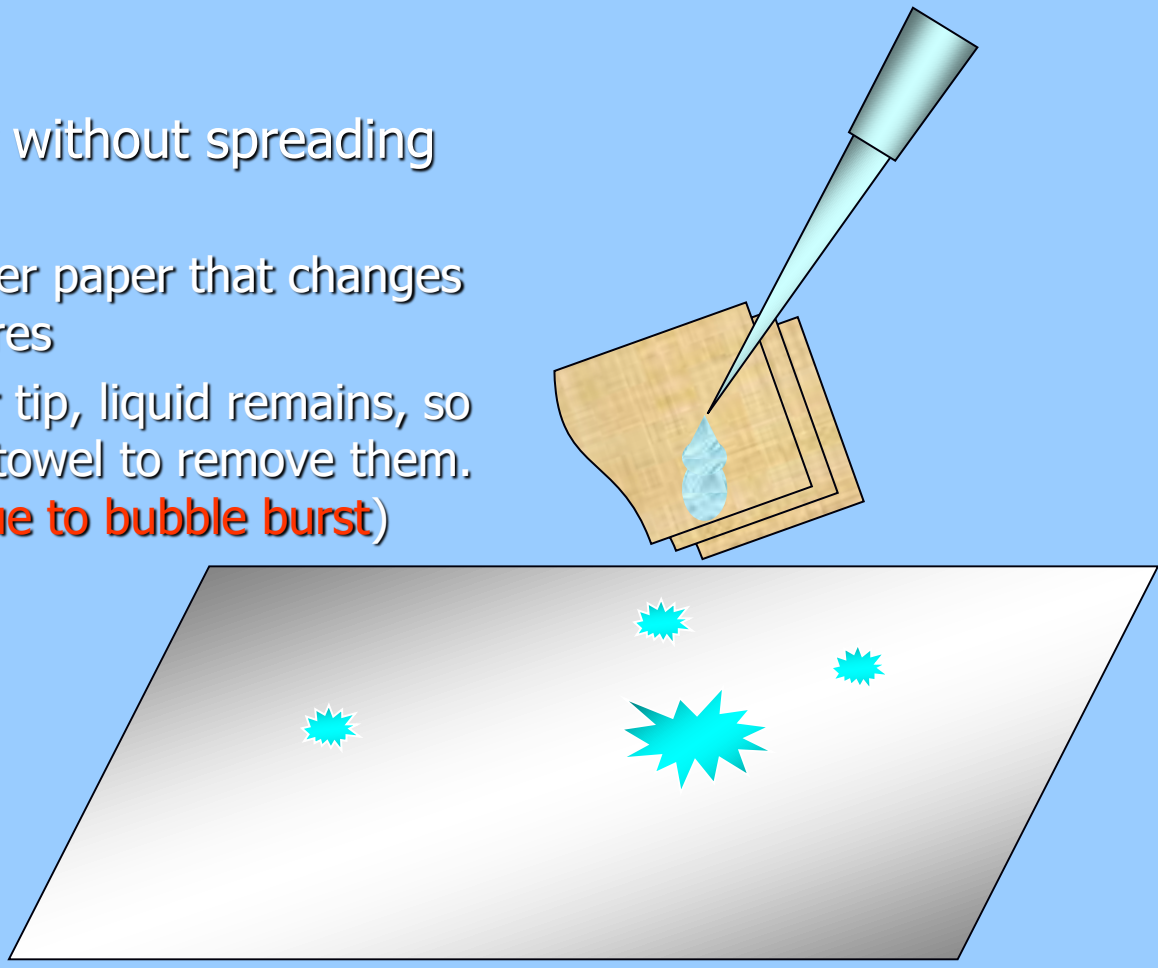
^{3}H、^{14}C、^{35}S handling

- Contamination cannot be measured with a survey meter for 3H, 14C, and 35S.
- To experiment smoothly without spreading pollution ...
  - Change gloves and wash your hands (be careful of "drops" when washing your hands)
  - Put on rubber gloves on the surgical gloves and change only the rubber gloves frequently.
  - If you double the gloves, you don't have to worry about sudden damage to the gloves.



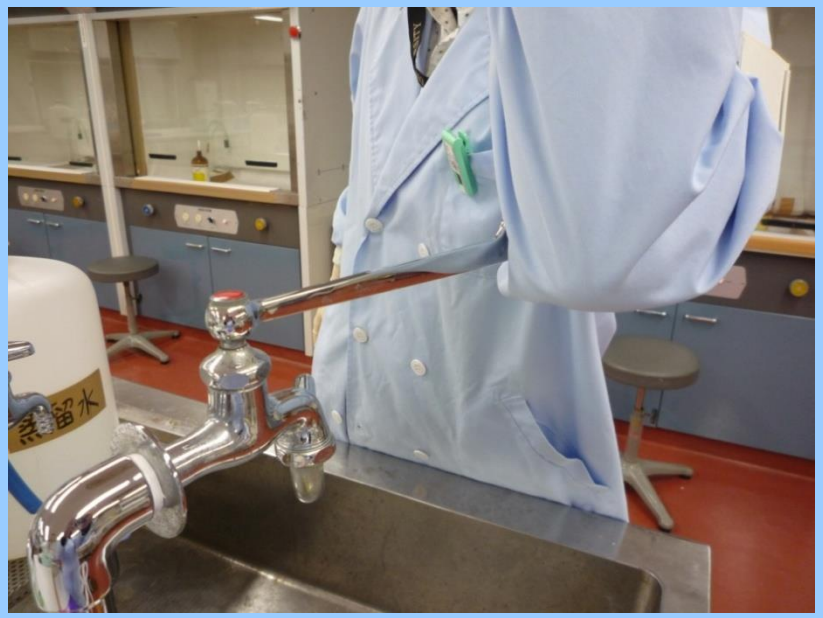
^{3}H、^{14}C、^{35}S handling

- To experiment smoothly without spreading pollution ...
  - Use of polyethylene filter paper that changes color when liquid adheres
  - After using a pipette or tip, liquid remains, so absorb it with a paper towel to remove them. (Prevention of flying due to bubble burst)



参考資料：RIの逆襲（秀潤社）

How to use the sink/water faucet



- Do not contaminate the faucet lever (operate with elbow)
- Prevent splashes and drops from falling to the floor

Cases of contamination by unsealed RI

1. Contamination of trousers and shirts
   … Wearing working clothes
2. Contamination of the cuffs of the working clothes
   … Cuff squeezing
3. Finger contamination
   … Wearing gloves, checking pinholes
4. Contamination of laboratory tables, etc
   … Use of filter paper and bats, fall prevention
5. Contamination of laboratory equipment and floors
   …Use of hoods and glove boxes,
   Check for contamination of gloves,
   Use of transport containers (bats, buckets, etc.)
6. Corridor contamination
   … Be careful of slipper contamination
   (do not drop droplet)

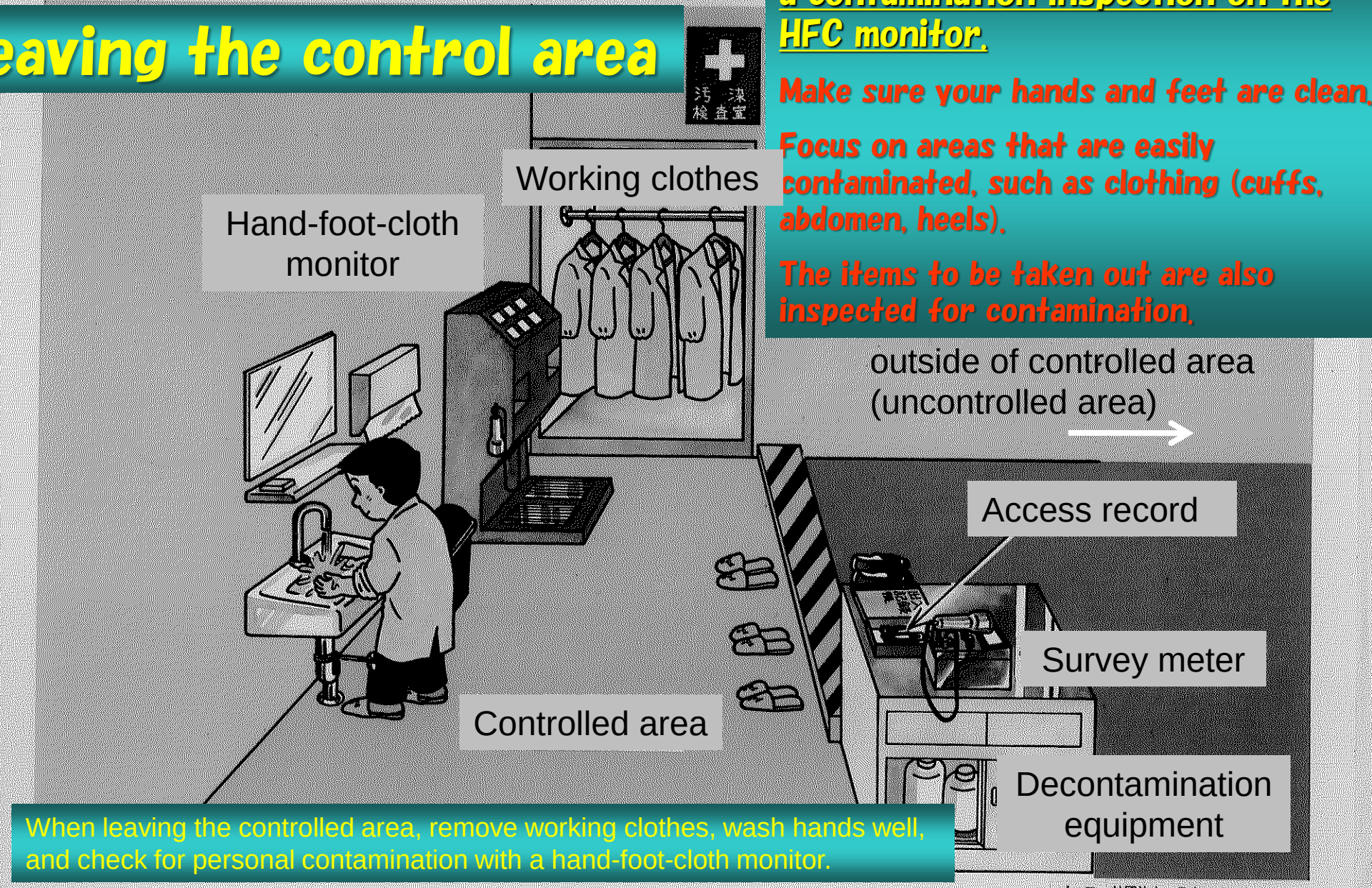
To avoid exposure to other radiation handlers

- By attaching a sign such as a radioactivity mark, the type, quantity, and location of **RI can be known to other people**.
  - Put a label on the one with radioactive isotopes attached.
  - Do not label or peel off that do not have radioactive isotopes attached.

- Do not borrow other people's equipment **without permission.**

- If contamination is detected, **notify the other people**. In addition, enclose the contaminated area with a permanent marker to prevent others from touching it.

eaving the control area



After washing your hands, perform a contamination inspection on the HFC monitor.

Make sure your hands and feet are clean.

Focus on areas that are easily contaminated, such as clothing (cuffs, abdomen, heels).

The items to be taken out are also inspected for contamination.

When leaving the controlled area, remove working clothes, wash hands well, and check for personal contamination with a hand-foot-cloth monitor.

Points for safe handling

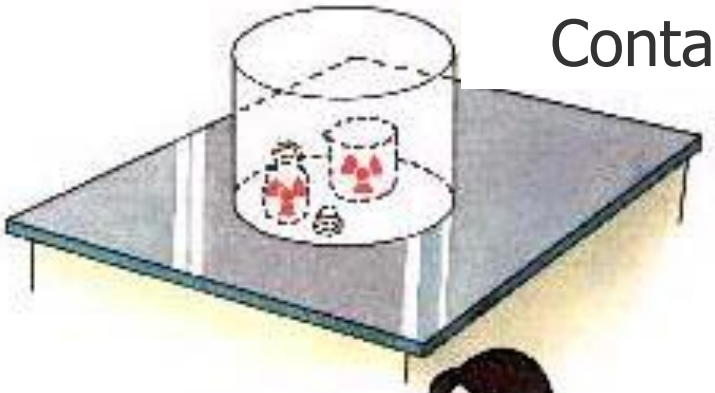
Unsealed *RI*

Pay attention to ：

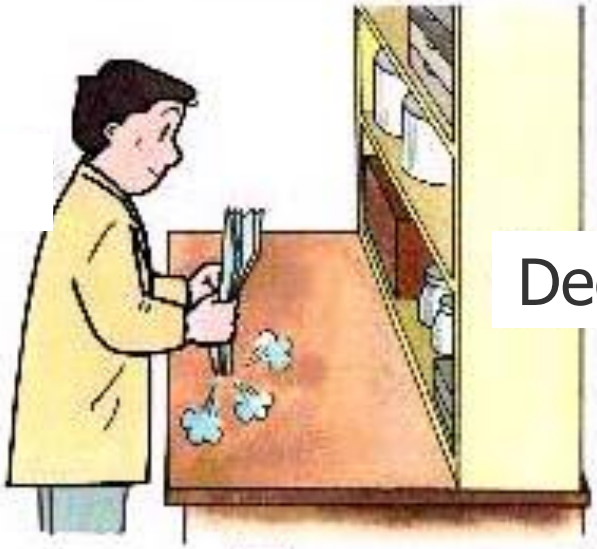
- External exposure
- Internal exposure
- Contamination
- pride and carelessness

Principle of unsealed RI handling

Contain



Decluttering



Cleanliness

Do not experiment alone

Finally・・・

- Radiation contributes significantly to medical care and research, but it can also cause serious accidents due to carelessness.

- If you do not understand something, do not judge it by yourself, consult with the supervisor.

- Not only you but others will be victims

  Please carry out the experiment, keeping in mind that it will cause a great deal of trouble to others.

Accidents

If you encounter any accidents such as fire or earthquake.

In case of accident

- At first, think and act to save yourself.
  - Escape to a safe place
  - Notify other workers in a loud voice
  - Push the emergency button
- If time permits, take action to prevent expansion of the accident.
  - Bring the radioisotope back to the storage room
  - Extinguish the fire at an early stage
- Notify the radiation protection supervisor or radiation protection staff members.

For working safely in the controlled area

- Understand the law concerning prevention from radiation hazards due to radioisotopes, etc.
- Understand the nature of radioisotopes and use them in an appropriate manner
- Understand the effects of radiation on humans and the environment
- Handle radioactive substances appropriately to prevent contamination
- Dispose of radioactive waste by authorized routes
- Follow the emergency procedures in case of natural disaster or fire

How to use hand-foot-clothes (H-F-C) monitor

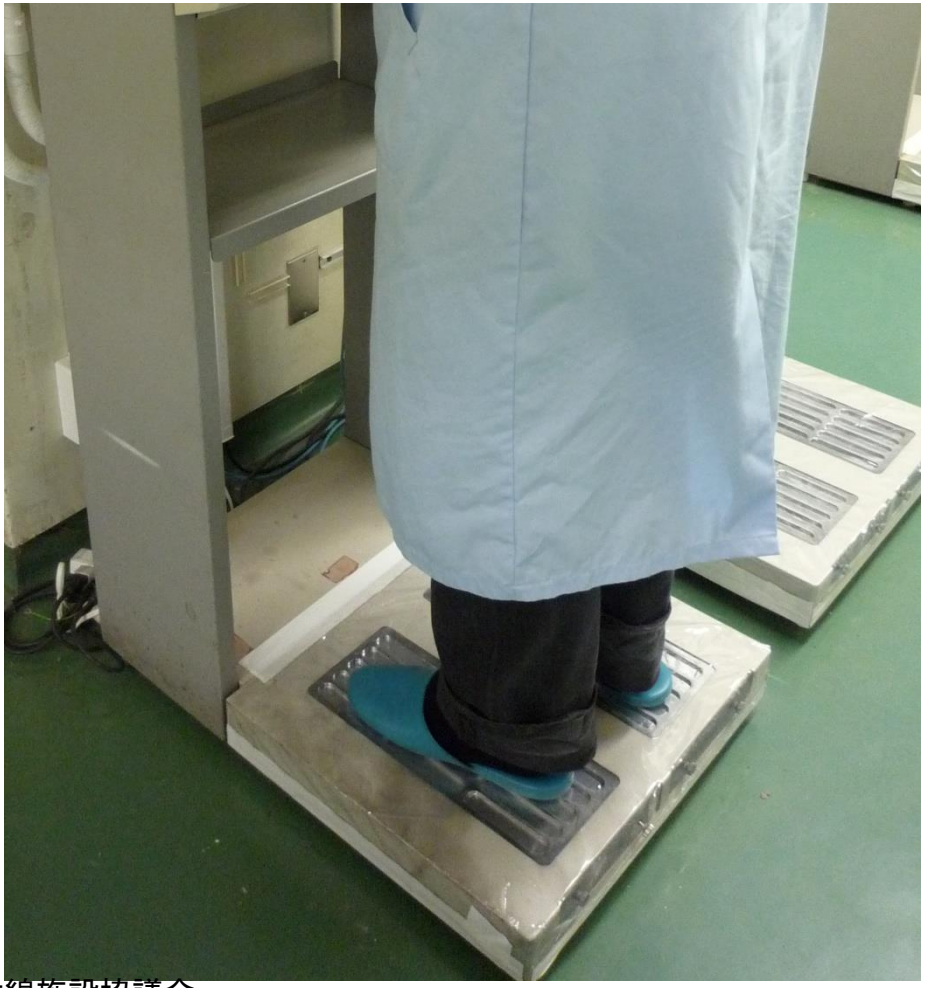
- Before you leave the radiation-controlled area, you have to confirm that you have no radioactive contamination by using a hand-foot-clothes monitor.

How to use hand-foot-clothes (H-F-C) monitor

1. Wash your hands carefully and dry your hands with a paper towel.

How to use hand-foot-clothes (H-F-C) monitor

2. Step on the H-F-C monitor with your slippers.

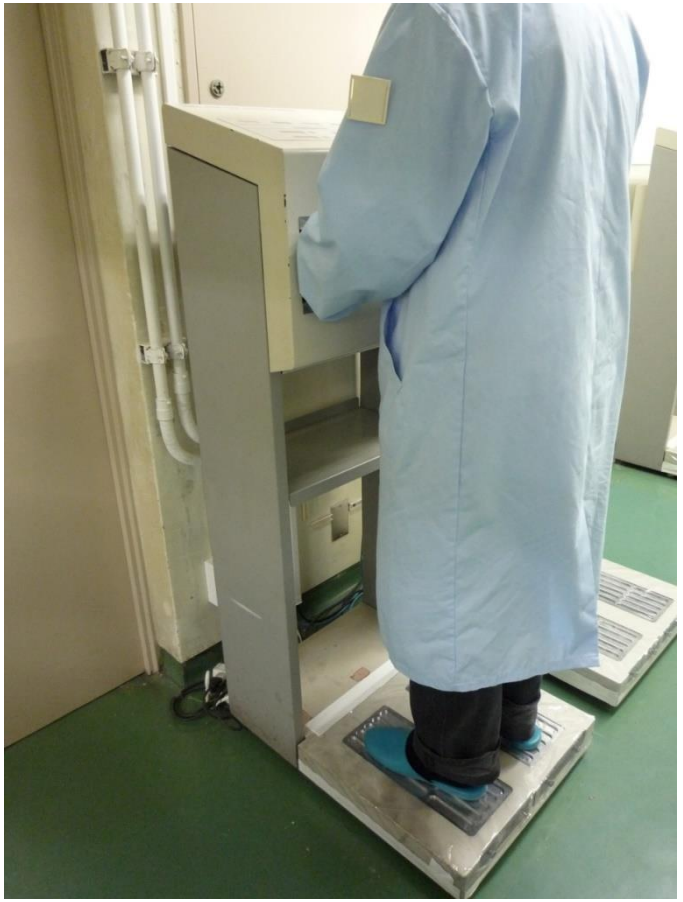


How to use hand-foot-clothes (H-F-C) monitor

3. Put your ID card into the card reader.

How to use hand-foot-clothes (H-F-C) monitor

4. Put your hands into the holes of the hand monitor. Your hands should push the switch on the bottom of each hole.



How to use hand-foot-clothes (H-F-C) monitor

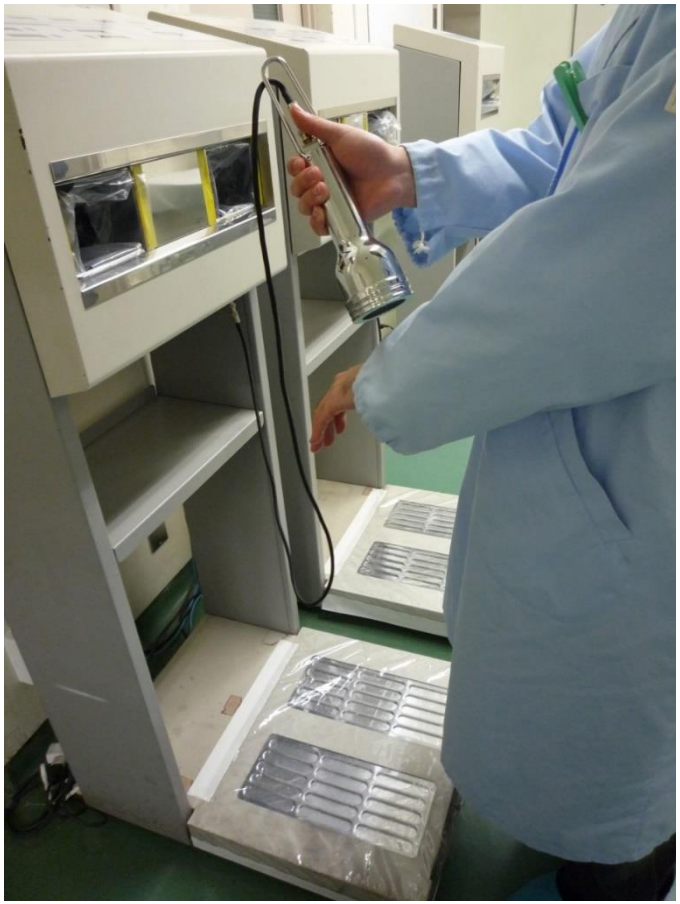
5. Wait 20 seconds until the green lamp shows that you have no radioactive contamination.

How to use hand-foot-clothes (H-F-C) monitor

If there is any radioactive contamination, the red lamp will light up and sound an alarm. In that case, you have to inform the instructor or the radiation control office immediately.

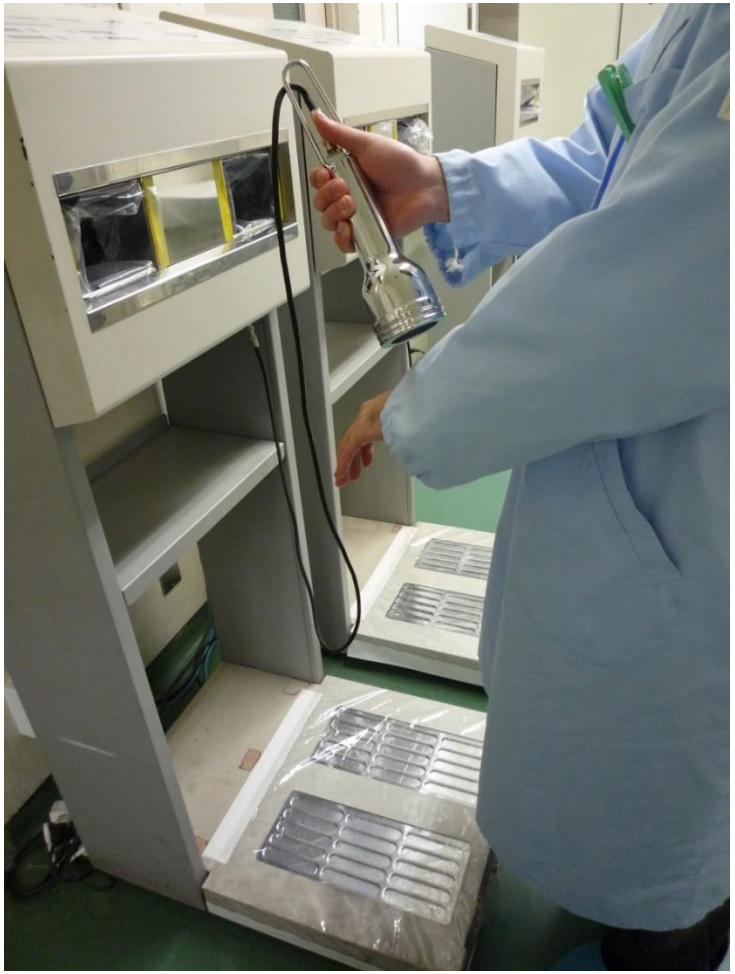
How to use hand-foot-clothes (H-F-C) monitor

6. Step off the board of the Foot monitor and take the monitor head of the clothes monitor on the right side of the H-F-C monitor.



How to use hand-foot-clothes (H-F-C) monitor

7. Check your clothes and all other items for about 30 seconds. The lab coat is most likely to show radioactive contamination on the sleeves, abdomen and pocket.



How to use hand-foot-clothes (H-F-C) monitor

8. Put back the monitor head on the hook of the H-F-C monitor. A green lamp on the card reader means that you have no radioactive contamination.

How to use hand-foot-clothes (H-F-C) monitor

If there is any radioactive contamination, the red lamp will light up and sound an alarm. In that case, you have to inform the instructor or the radiation control office immediately.