

Recovery from the great earthquake in 2011 and a radioactive material leak incident at J-PARC in 2013

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- ◆ **The Great East Japan Earthquake on March 11, 2011.**
- ◆ **Radioactive material leak incident at the J-PARC Hadron Experimental Facility on May 23, 2013.**

Great East Japan Earthquake (2011 earthquake and tsunami)

14:46 on March 11, 2011

A powerful earthquake of magnitude 9.0 hit the east Japan.

Maximum (Japanese seismic) **scale 7** at Miyagi

Huge Tsunami on Pacific Coast

Dead or missing persons : **>18,000**

Largest disaster in Japan

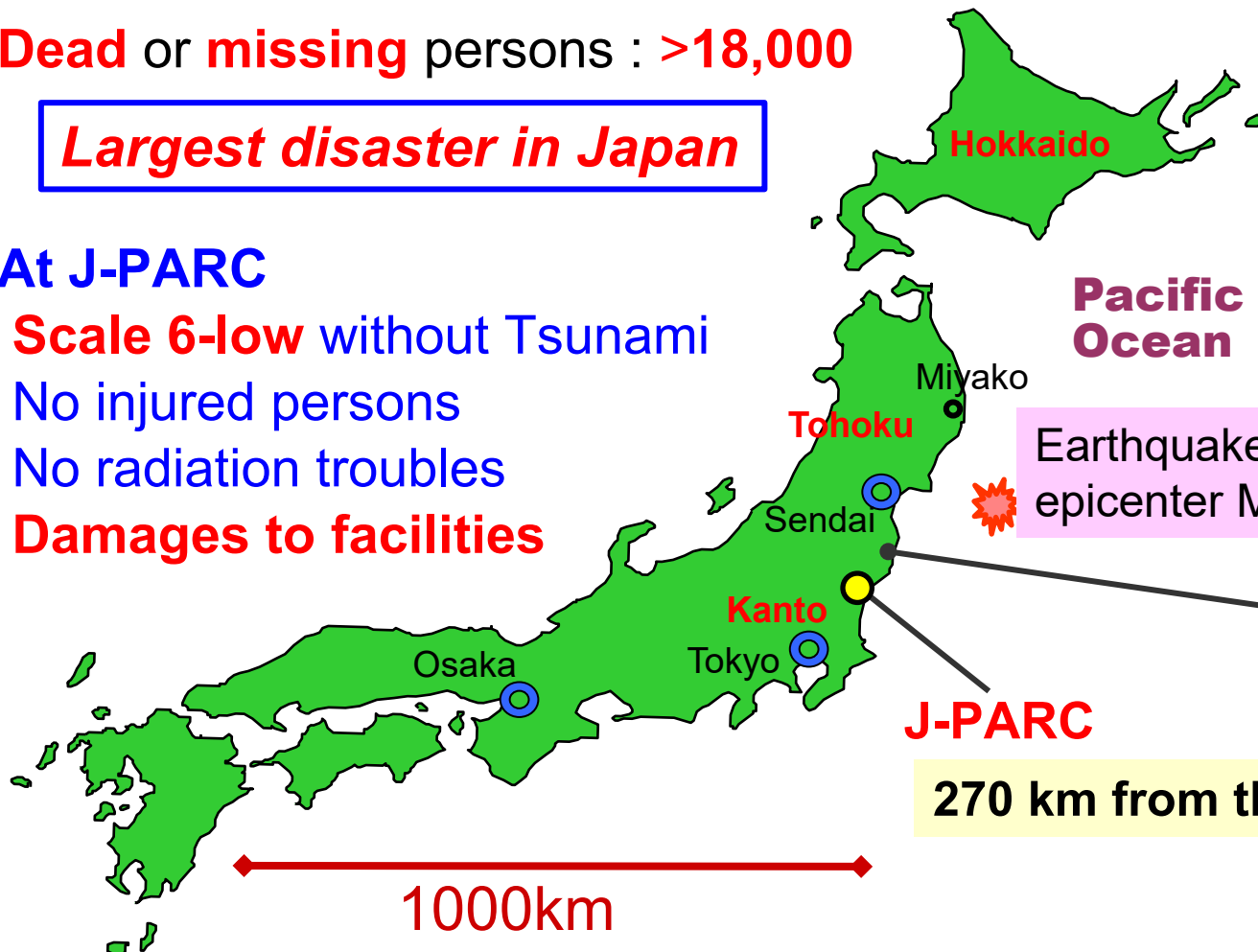
At J-PARC

Scale 6-low without Tsunami

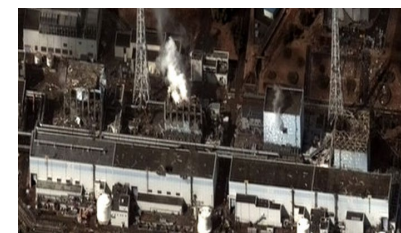
No injured persons

No radiation troubles

Damages to facilities



Tsunami disaster (40mH at Miyako)

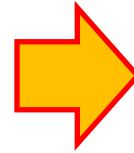


Nuclear accident at Fukushima NPPs

Outside LINAC main building



Serious cracks on the road



Ground caved in at many places
Electric cable & water piping damaged



Inside LINAC tunnel



LINAC tunnel : 15 m underground

Groundwater slowly flew into the tunnel. (~10 cm / ~100 tons).

- Draining water
- Waterproofing repairs



Outside MLF main building



Ground damaged
Units tilted, damaged

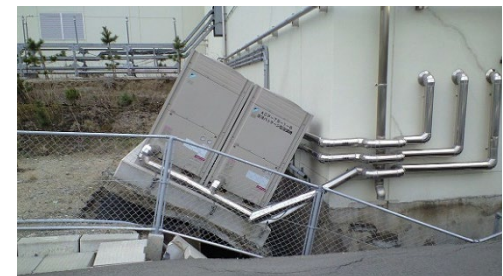


Water/gas pipes broken



At NU facility

Outdoor units
damaged



Inside MLF experimental hall

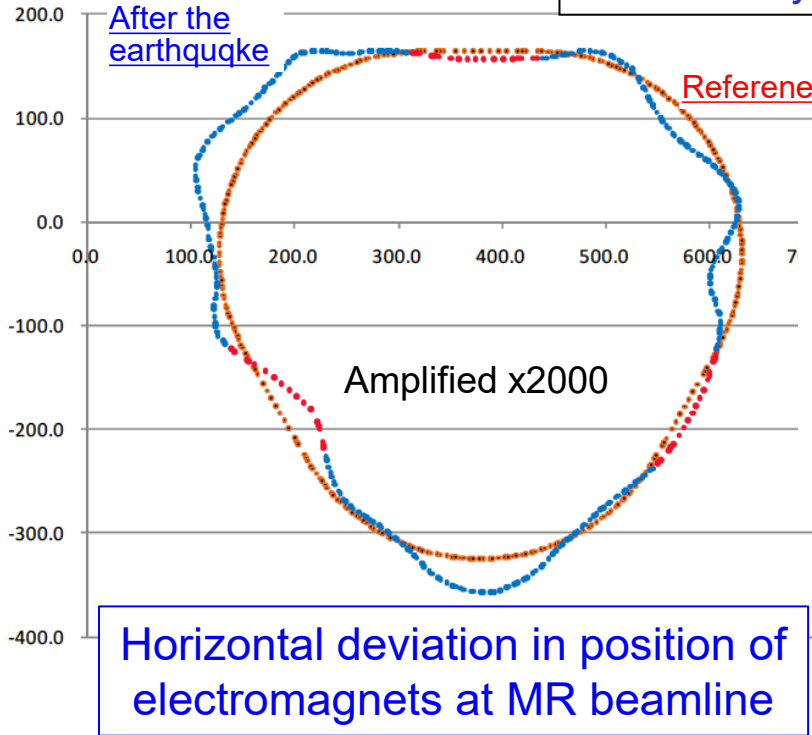
No obvious damage to main buildings
Concrete shielding blocks moved by large shaking



530 blocks of 2800 tons were reassembled and realigned in the MLF exp. hall.

Misalignment of electromagnets at accelerator and beamline

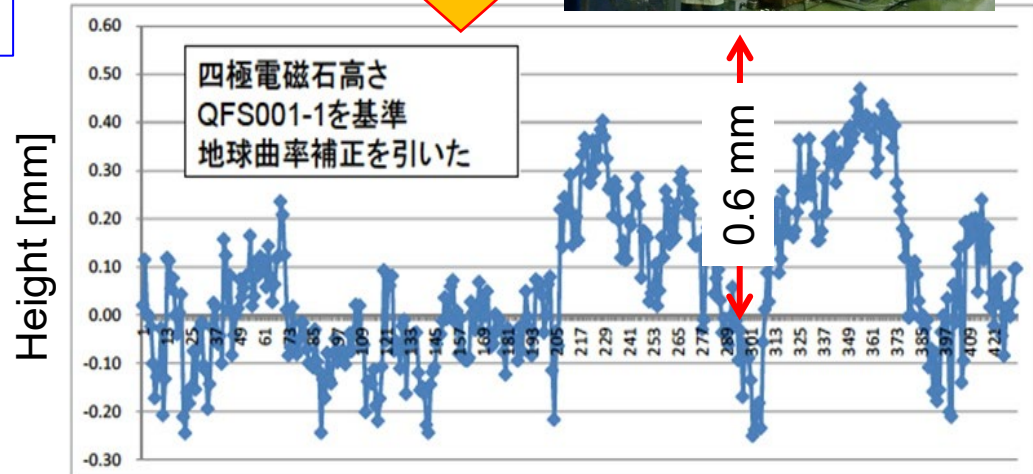
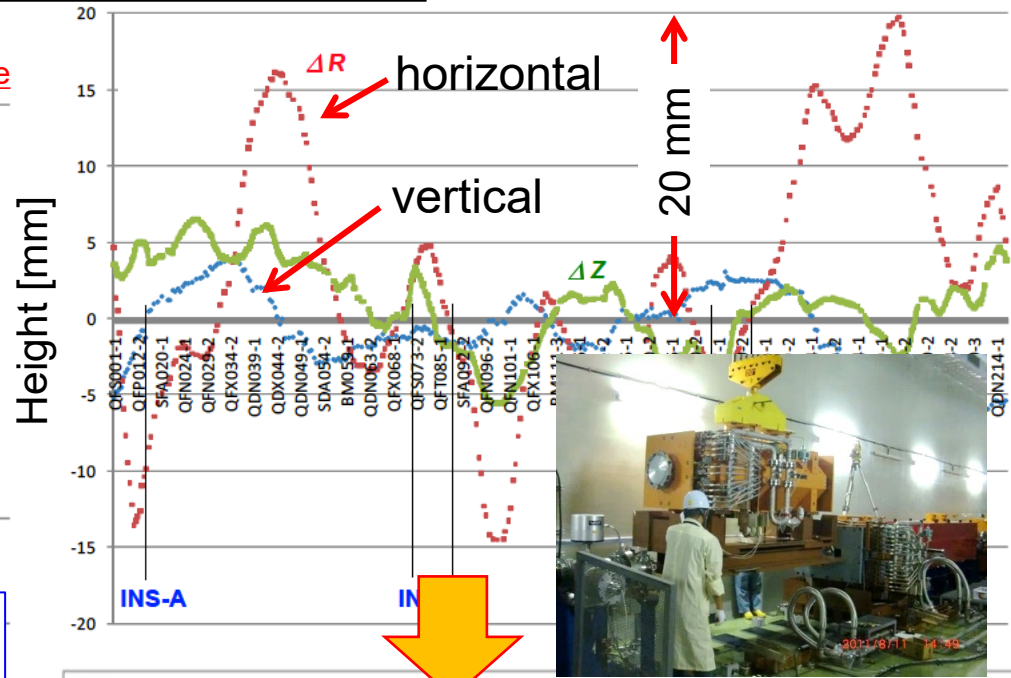
Immediately after the earthquake



misaligned ~ 20 mm (horizontal)
~ 8 mm (vertical)
for 400 electromagnets

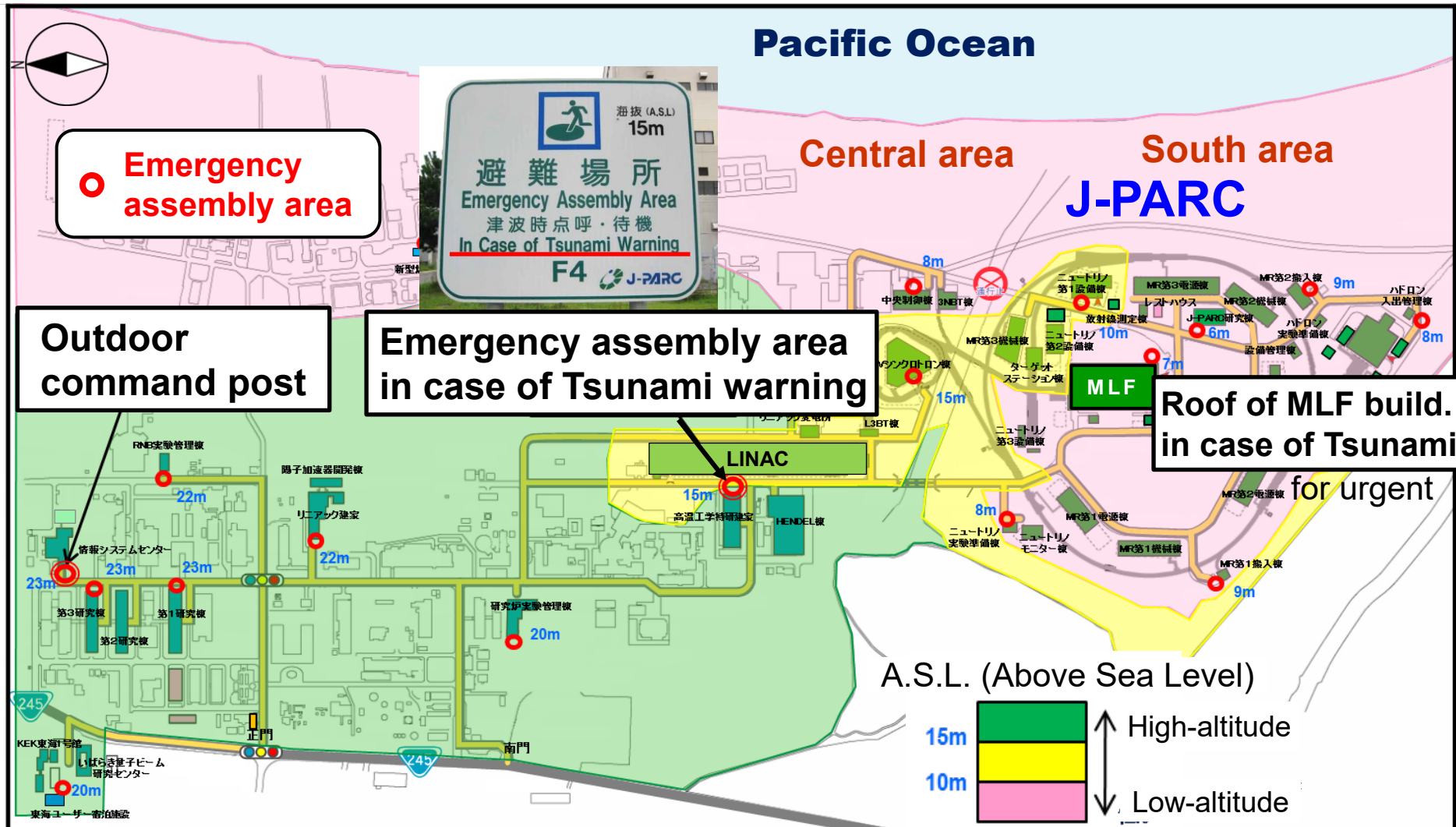


Adjusted to
within 0.4 mm deviation



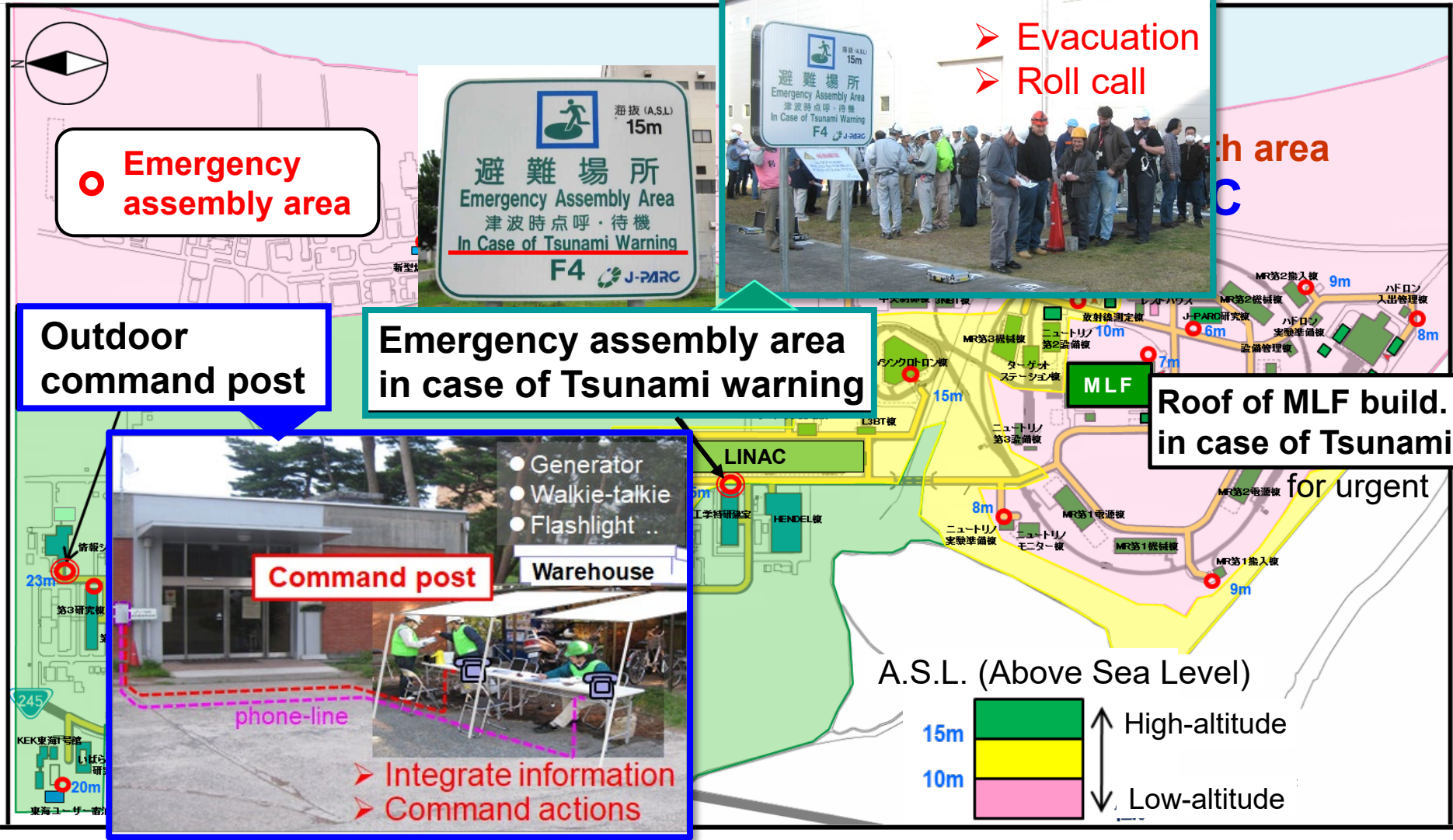
(Preparedness for large earthquake)

Setting emergency assembly areas and outdoor command post on high-altitude area



(Preparedness for large earthquake)

Setting emergency assembly areas and outdoor command post on high-altitude area

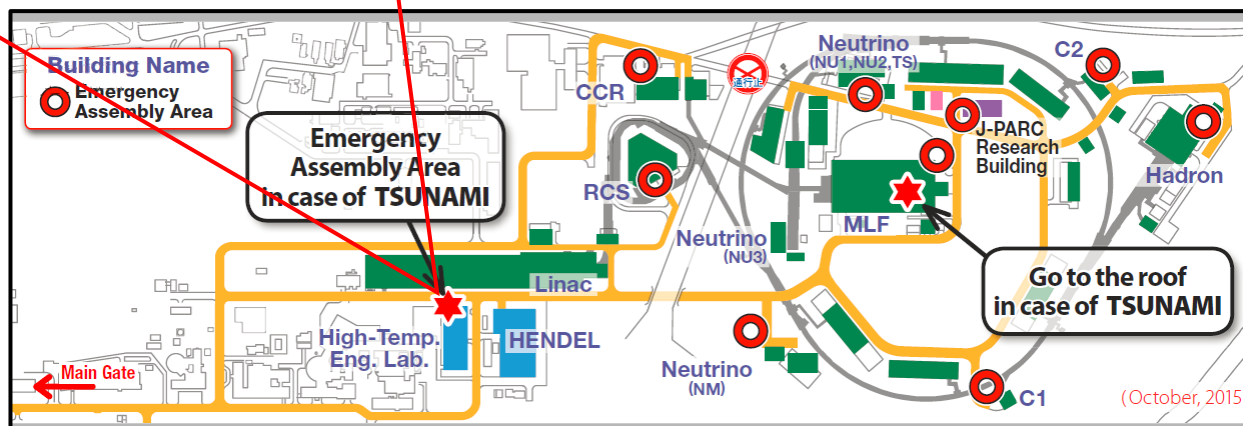


(Preparedness for large earthquake)

Emergency drill for large earthquake every year

➤ Confirming procedures for evacuation, roll call, reporting

Roll call at the emergency assembly area



Earthquake Damage and Recovery

Impact of the Earthquake on Mar. 11, 2011.

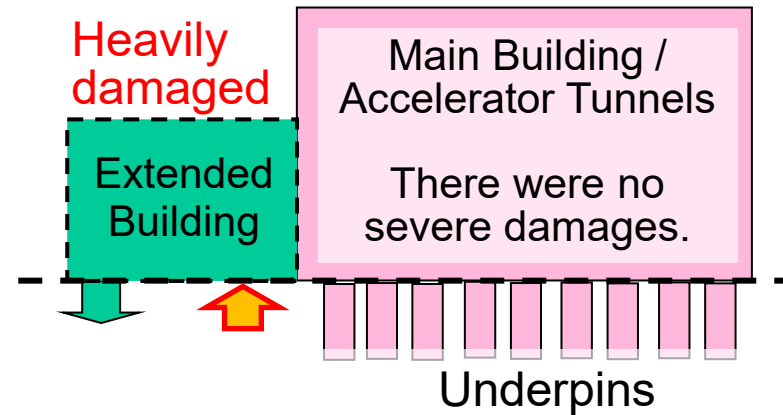
- Damage of the main facilities was large but not fatal.
 - No obvious structural damage to main buildings and accelerator tunnels due to many underpins supporting the building.
- More serious damages were found on extended buildings, outside units, electric cables, gas/water pipes, etc. ⇒ **Repair works**
- No Tsunami damage, no injury, no radiation troubles



Restart beam
on Dec. 9, 2011



Beam operation to
MLF on Dec. 22, 2011

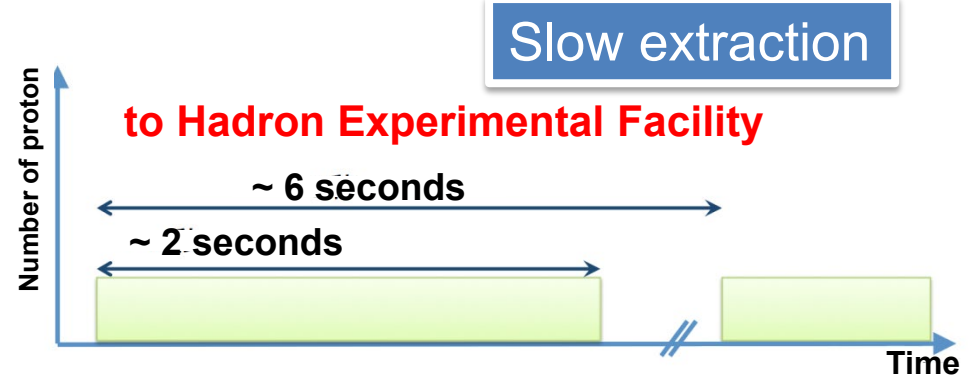
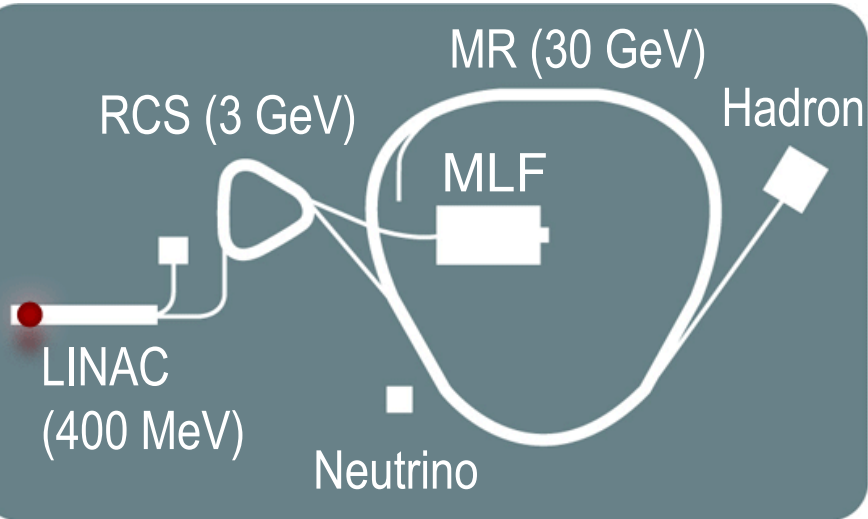


User operation
on Jan. 24, 2012

10months

Radioactive Material Leak Incident at J-PARC in 2013

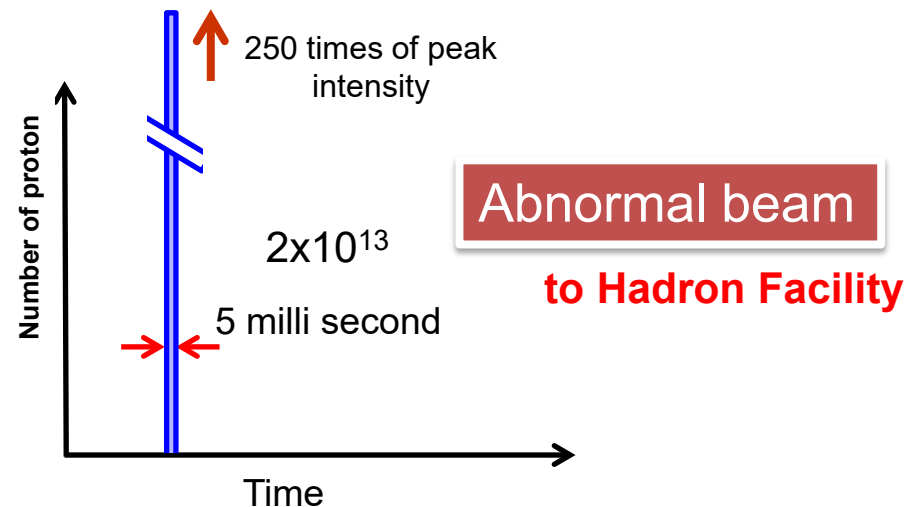
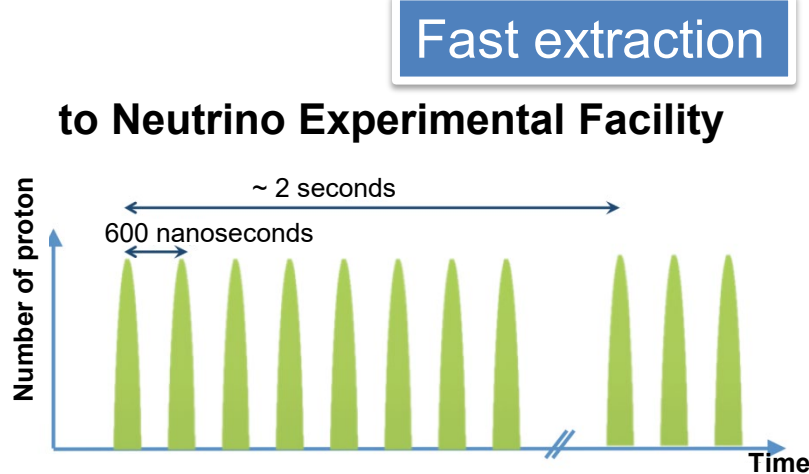
Beam extractions in J-PARC facilities



Malfunction of beam extraction system



An **abnormal proton beam** was injected to the gold target at **11:55 on May 23, 2013**.



Radioactive Material Leak Incident at J-PARC in 2013

What happened.

1. Abnormal beam hit the target

Heating of the Au target to melting

Release of radioactive material

=> inside target chamber *insufficient air-tightness*

2. Leak of the radioactive material

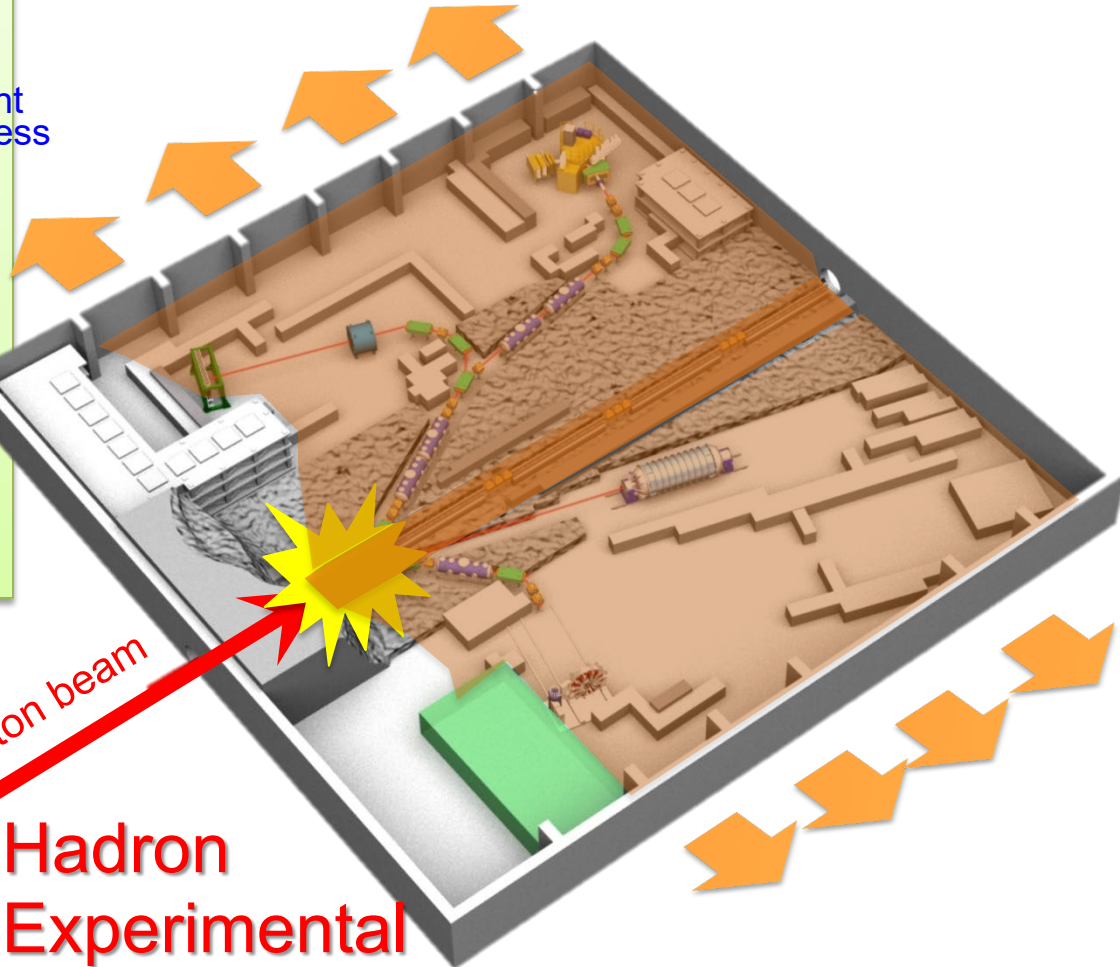
=> primary beamline *insufficient air-tightness*

=> experimental hall

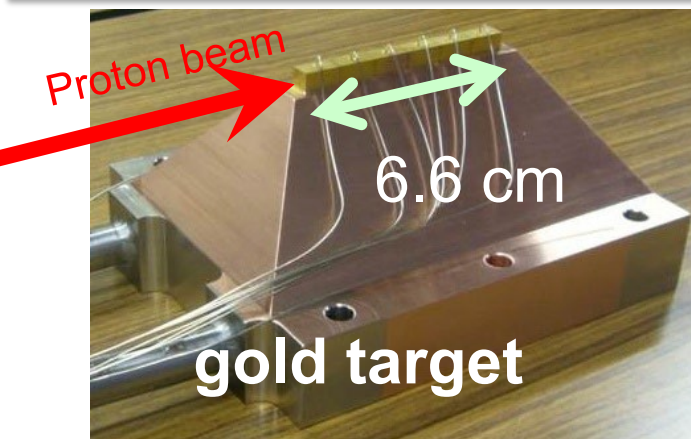
Workers exposed to radioactivity.

3. Release of the radioactive material

=> **Outside of the controlled area**
through the ventilation fans



**Hadron
Experimental
Facility** 60m x 56m



gold target

Radioactive Material Leak Incident at J-PARC in 2013

What happened.

1. Abnormal beam hit the target
Heating of the Au target to melting
Release of radioactive material
=> inside target chamber insufficient air-tightness
2. Leak of the radioactive material
=> primary beamline insufficient air-tightness
=> experimental hall
Workers exposed to radioactivity.
3. Release of the radioactive material
=> **Outside of the controlled area**
through the ventilation fans

Radiation exposure on workers

: Max. 1.7 mSv

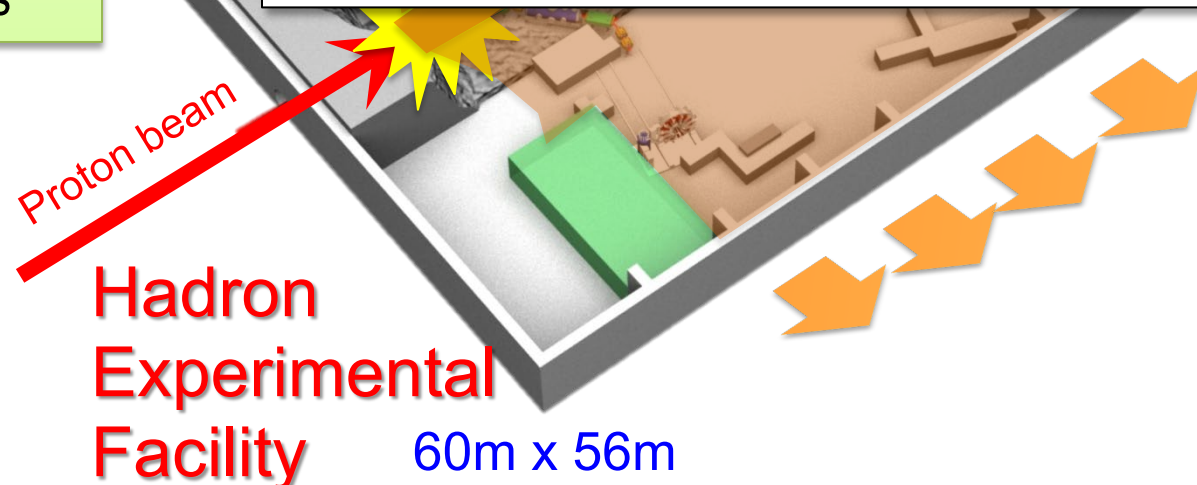
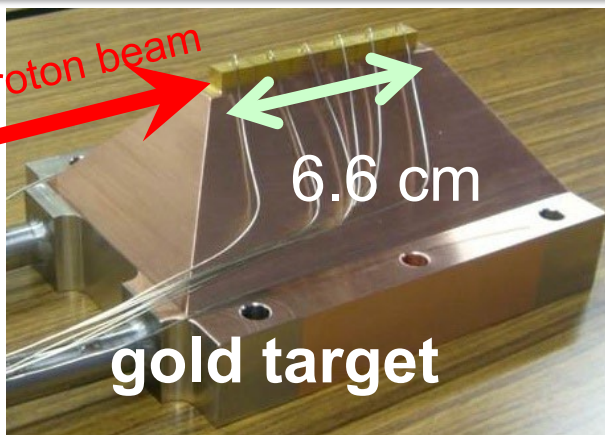
Integrated dose at the site boundary

: Max. 0.17 μ Sv

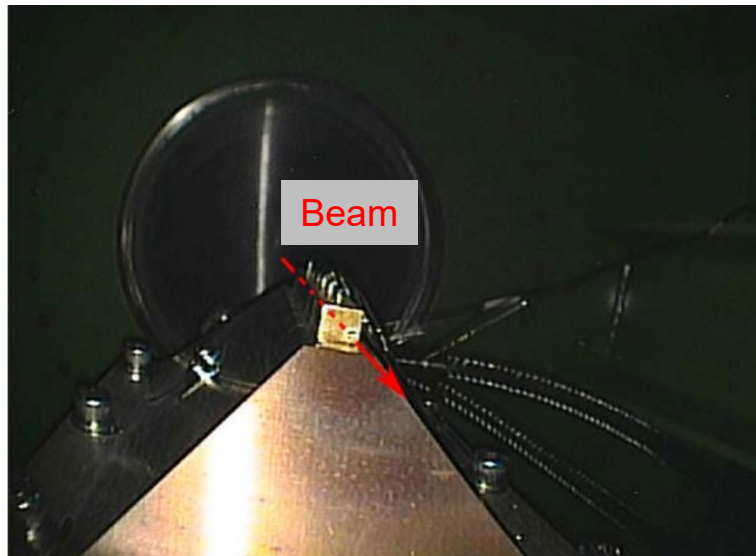
violate the regulations on radiation protection according to the law.

⇒ Radiation accident with notification required

Operation of all J-PARC facilities were stopped.

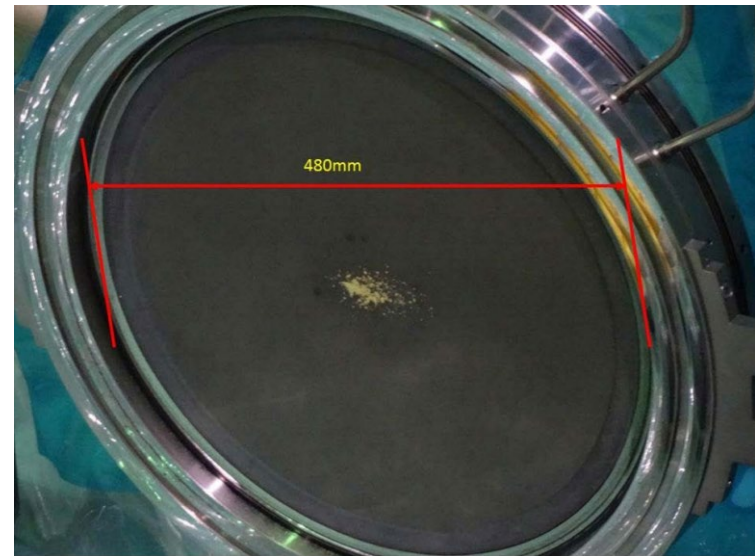


Target observation 6 months after the incident



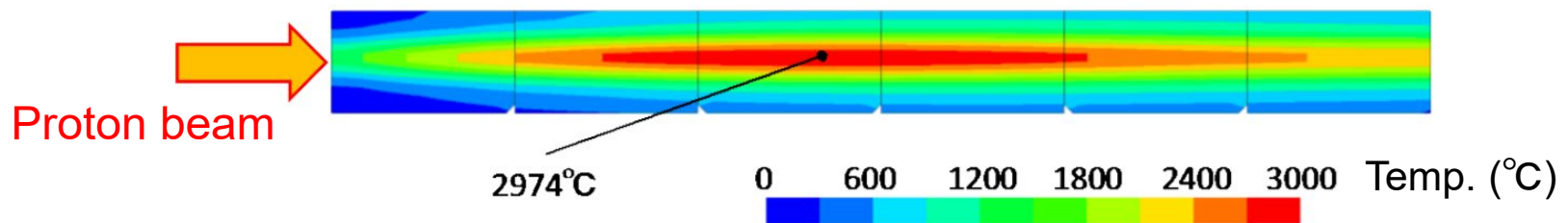
Gold target viewed from downstream side of the proton beam

- ◆ ~ 1 mm hole was observed.



Beam window behind the gold target

- ◆ Gold splash was scattered on the beam window towards the beam direction.



Calculated temperature profile immediately after the abnormal shot.

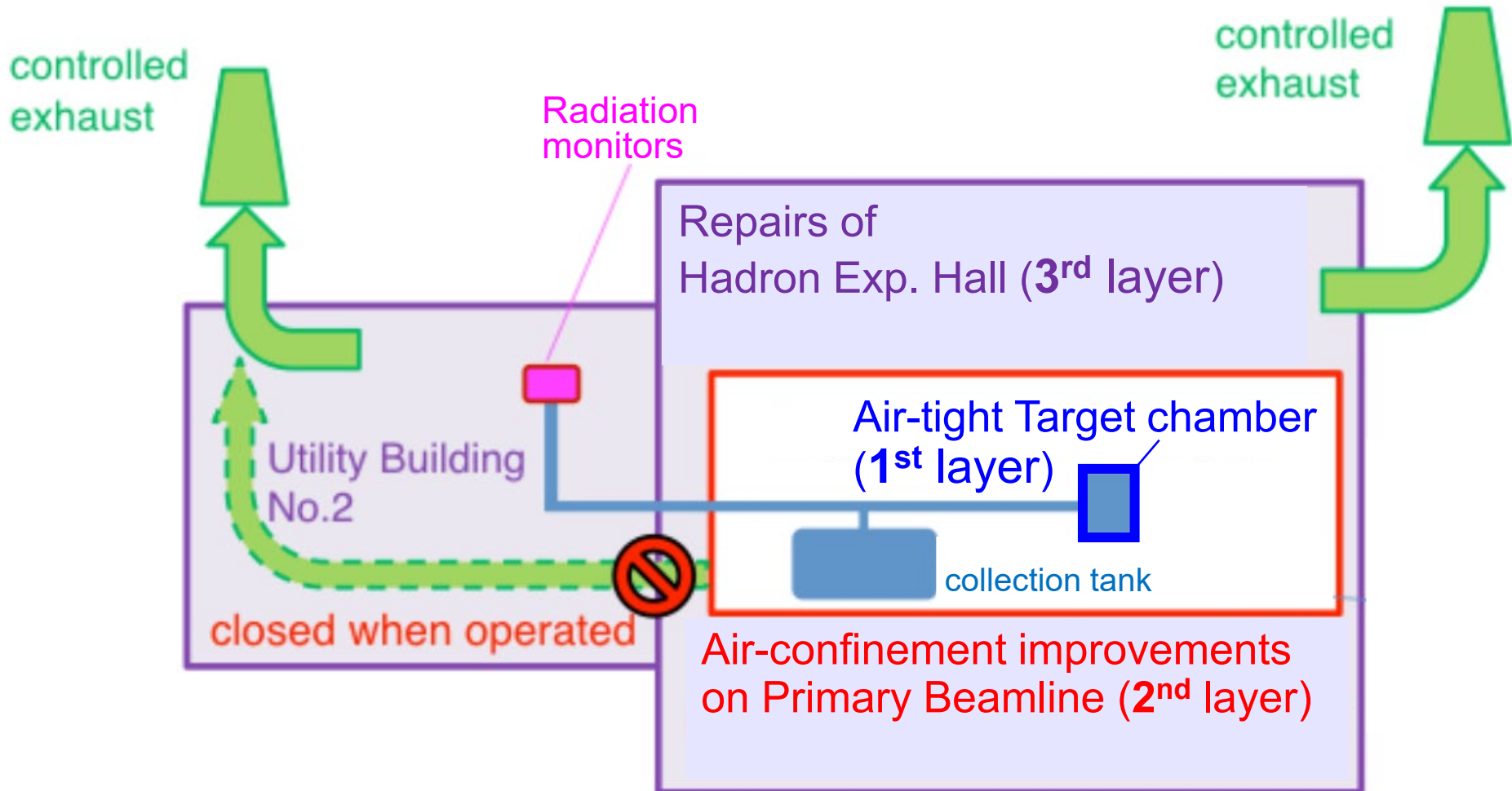
Gold (Au) melting point : 1064°C, boiling point : 2856°C

Au ⇒ liquid, gas

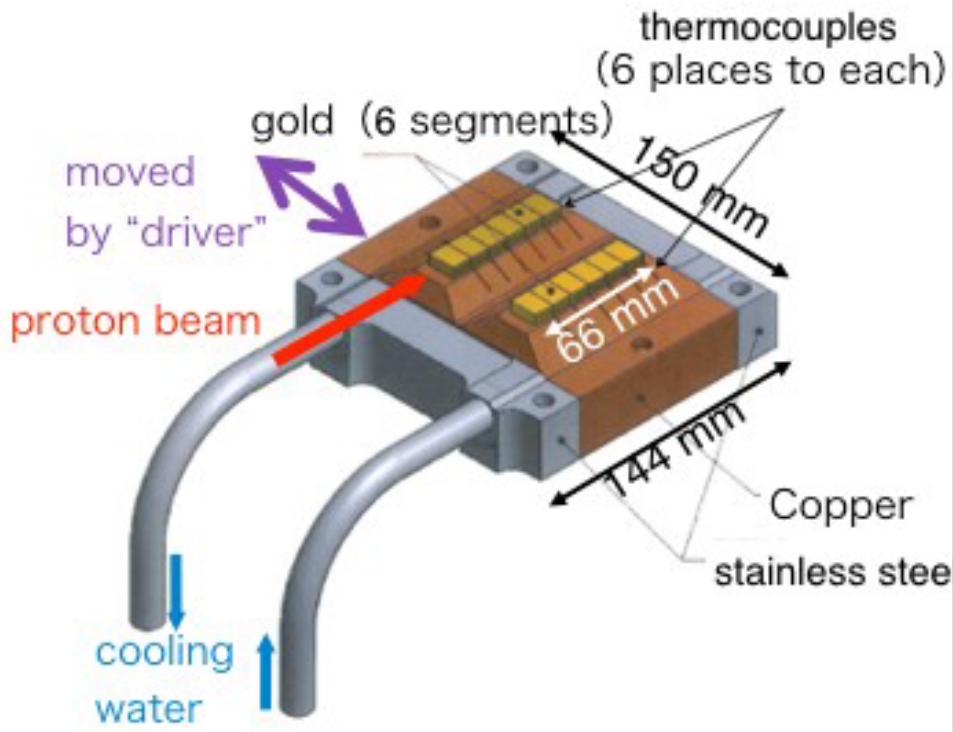
Important concept in countermeasures
against recurrence of similar accidents

“Multi-layer protection” for target failure

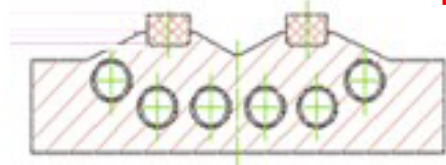
Confinement of radioactivity inside



newly-designed Target System after the incident



Cross-sectional view



Widen the beam size

$$(\sigma_x, \sigma_y) = (0.6 \text{ mm}, 0.6 \text{ mm}) \rightarrow (2.5 \text{ mm}, 1.0 \text{ mm})$$

widen the cross-section of the target, as well

$$6 \text{ mm} \times 6 \text{ mm} \rightarrow 15 \text{ mm} \times 6 \text{ mm}$$

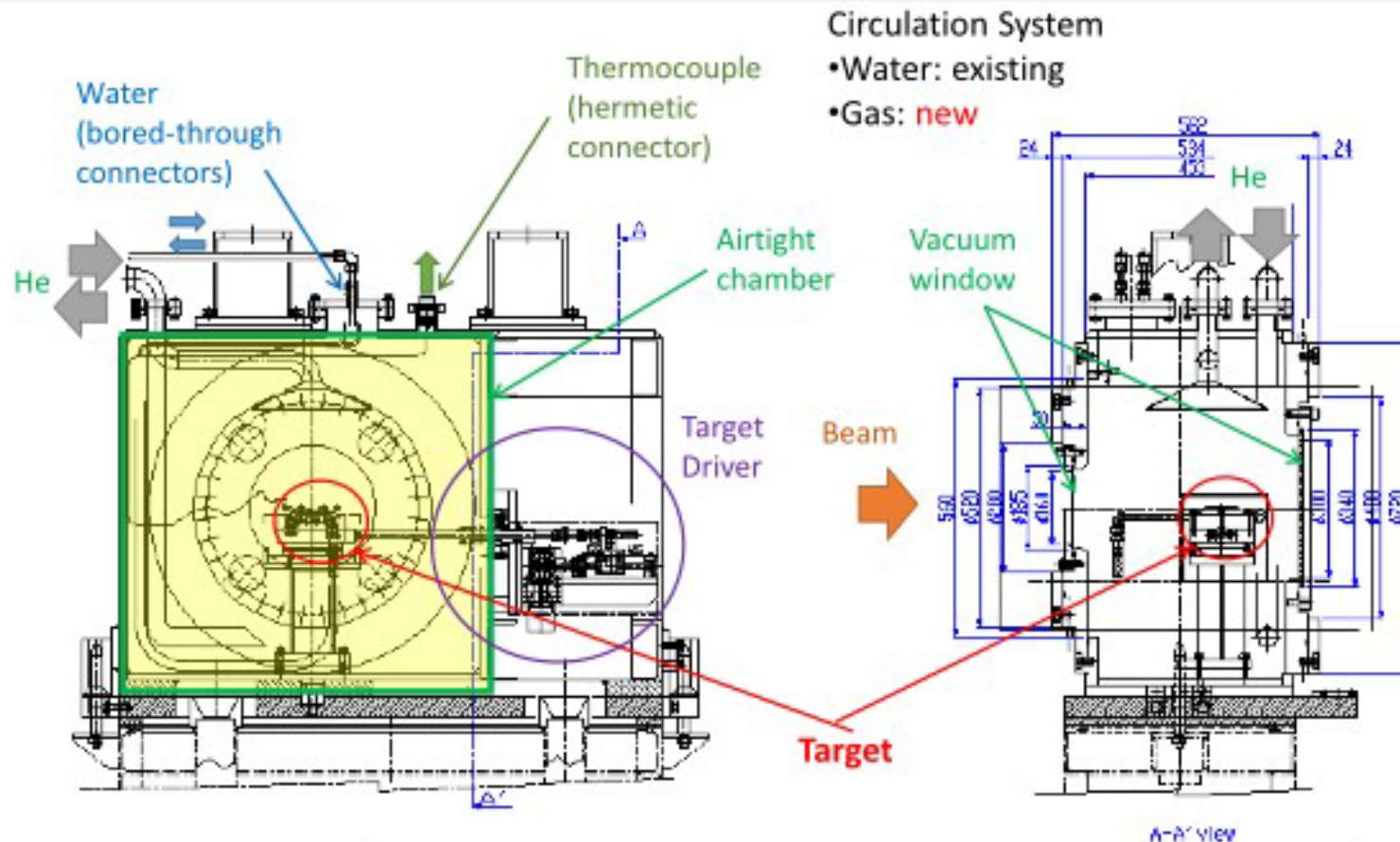
(improvements)

- “two targets” in the chamber,
“driver” to move the target

When target monitors indicate the target cooling deteriorates, we will “replace” the target before it gets into trouble.

- Water-cooled;
cooling-pipe location
- Temperature-monitor readout every sec → every 0.1 sec

newly-designed Target Chamber after the incident



(improvements)

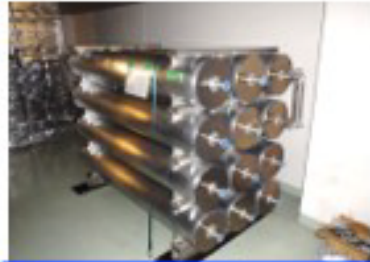
- air-tight chamber, He-gas circulation
- slinging hanger for remote handling

Target Watch : He-gas circulating system

Radiation monitors :

Ge detector γ -ray spectrum

NaI(Tl) det. γ -ray count rate



He buffer tank



He-gas collection tank (main)

protons

target system

Utility Building No.2
(HM2)



(new, for countermeasures)
(in trouble)

– collect the He gas in the chamber
by the collection tank (main)

(continuous watching)

– watch the radiation level of the He gas
to confirm the soundness of the target

– filter the radioactive materials/impurities

Hadron
Hall

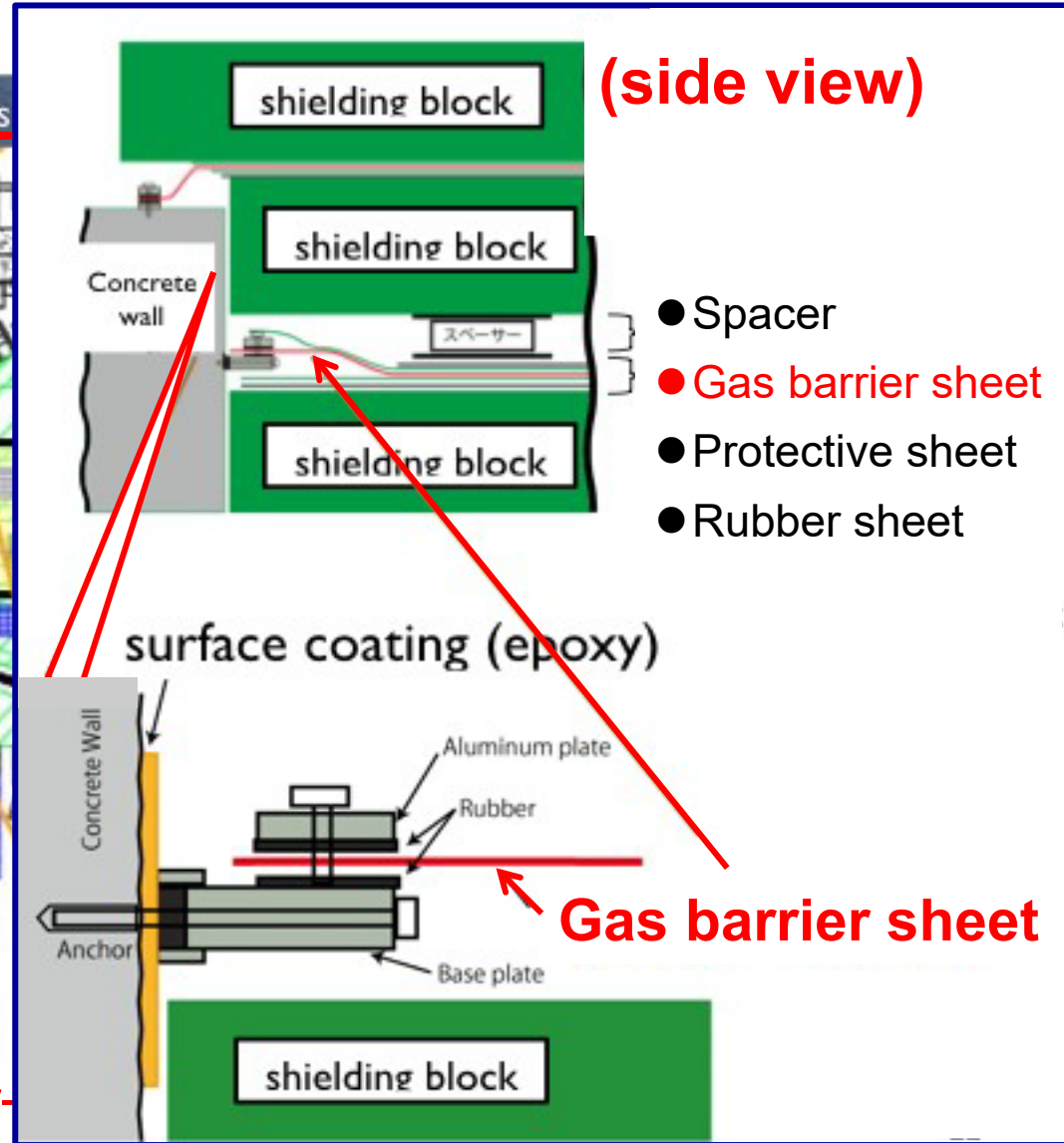
Improving Air-confinement of Primary Beamline

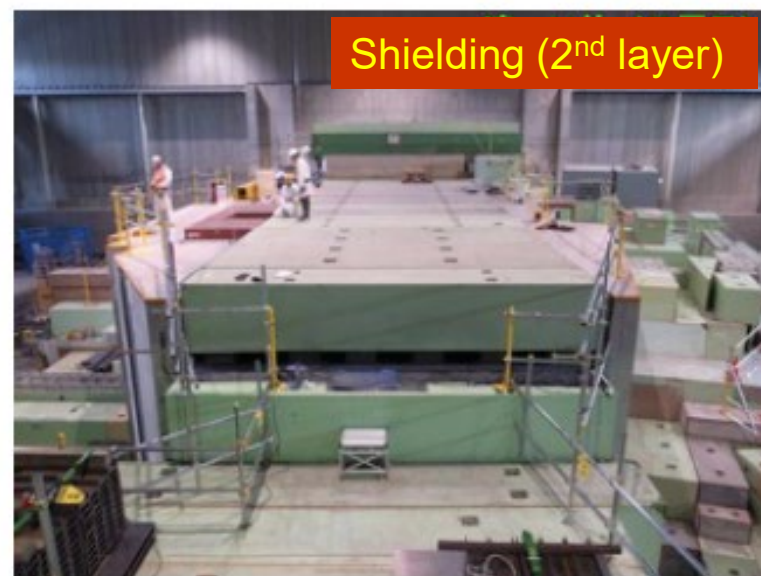
(plane view)



weak part in air-

(side view)





Air-tight upper shielding **completed**



Other Countermeasures in Hardware

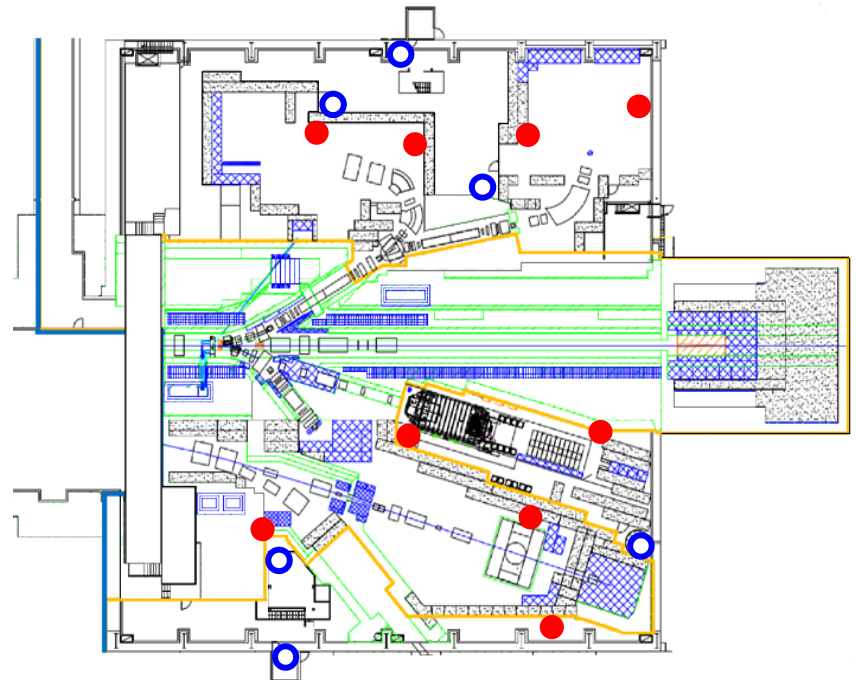
(Examples)

- ◆ Preventive measures for malfunction of power supply
- ◆ Beam interlock strengthened and speeded up
- ◆ Sharing information on radiations for workers in the hall

- Radiation display
- Speaker and flashlamp



➡ Evacuation outside



Restarting J-PARC facilities

- May 23, 2013 Radioactive material leak incident
- Feb. 17, 2014 Restart user-beam operation at MLF
- May 26, 2014 Restart user-beam operation at NU
- Apr. 24, 2015 Restart user-beam operation at HD

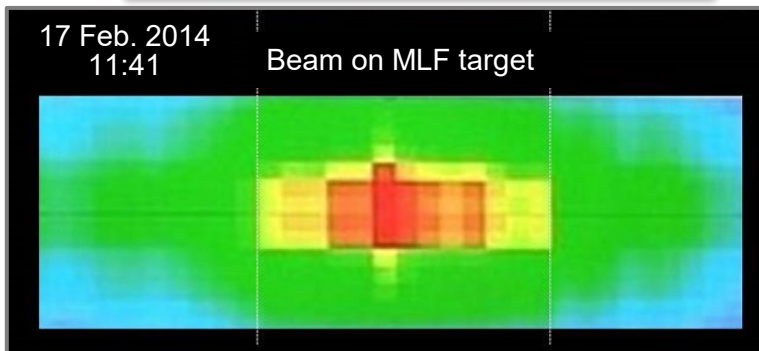
All facilities at J-PARC restarted.

2years

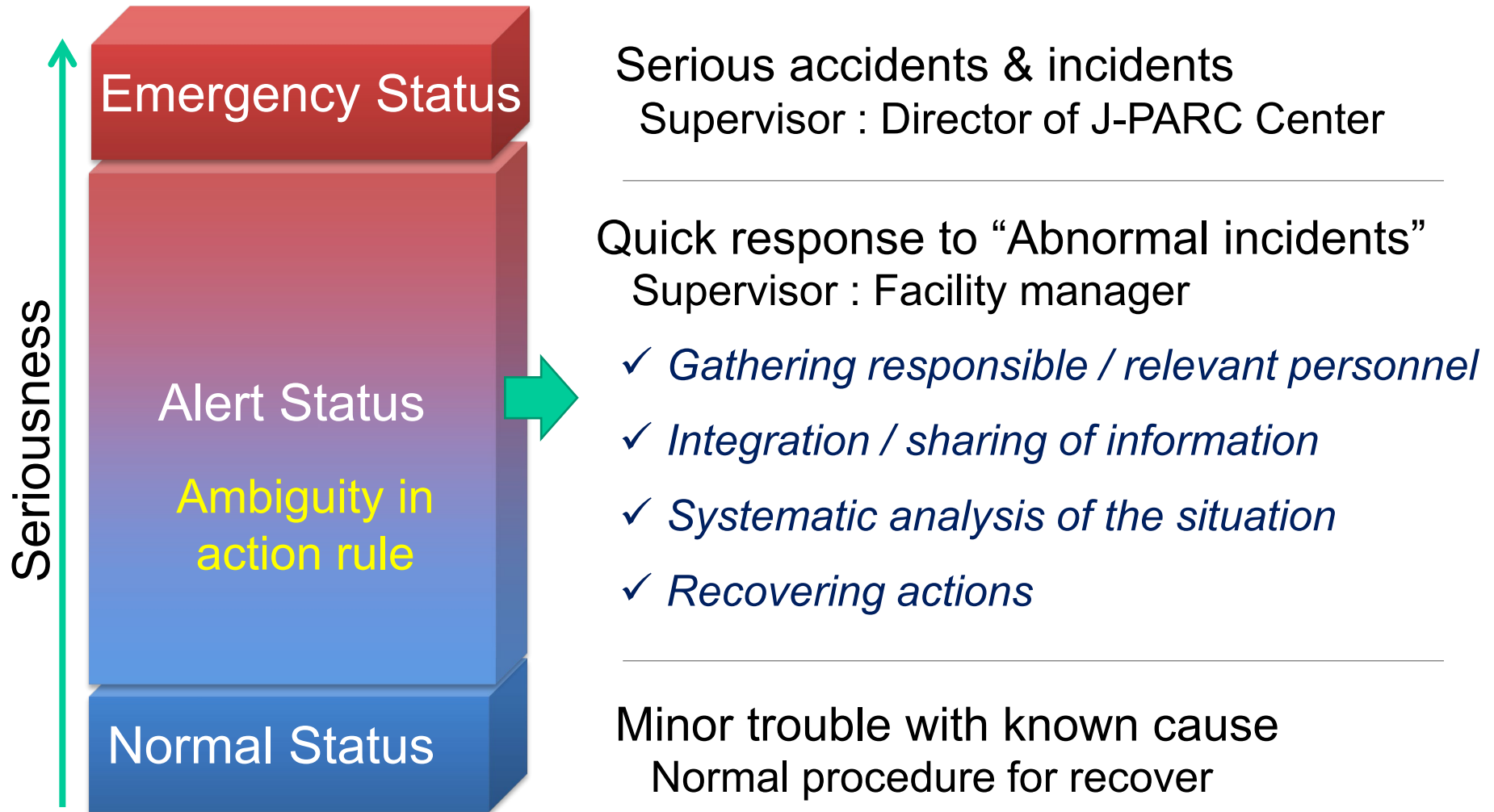
MLF



HD



Introduction of “Alert Status” respond to abnormal situations



Examples of setting the Alert Status

- Alert of mercury sensor in the MLF target vessel
- Stoppage of the ventilation fan

Emergency drills for various situations

- Radioactivity leak incident
: simulated the incident in 2013
- Radiation exposure inside the accelerator tunnel
: serious neutron exposure to worker
- Worker contamination
: decontamination, transportation of worker
- Fire in rad-controlled area, accelerator tunnel
: evacuation, checking persons, fire extinguishing

Through these emergency drills,
we experience the required actions.
(quick, appropriate, cooperative..)



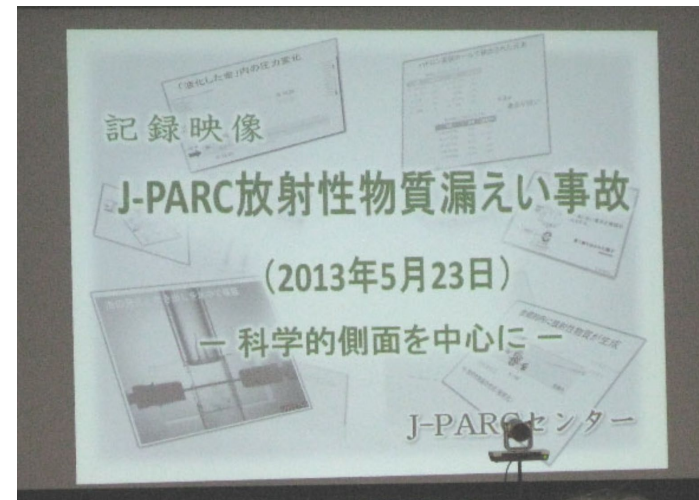
For continuous improving safety culture J-PARC Safety Day (Memorial day of the incident in 2013)

- **Not forget the lessons learned from the incident**
- **Think about one's own "Safety" continuously**

- ◆ Invited talks from other fields, airlines (ANA, JAL), railway (JR), Toyota Motor, Disney Resort, medical doctor, psychologist..
- ◆ Documentary video "Radioactivity Leak Incident at J-PARC"



“SAFETY at the Disney Resort”
by Mr. Ishizaka



Documentary video
“Radioactivity Leak Incident at J-PARC”

Recovery from the great earthquake in 2011 and the radioactivity leak incident in 2013

Preventive measures against similar emergency situations

For large earthquake with Tsunami risk

- ◆ Emergency assembly areas set on high-altitude area
- ◆ Repeating emergency drills for large earthquakes

For radiation accidents

- ◆ Various hardware countermeasures
- ◆ Alert Status respond to abnormal situations for cooperative and systematic actions.
- ◆ Emergency drills for various situations
- ◆ Continuous improving safety culture