Recovery of Linac after the Earthquake

SuperKEKB Accelerator Review, 2012. 2. 20

A. Enomoto

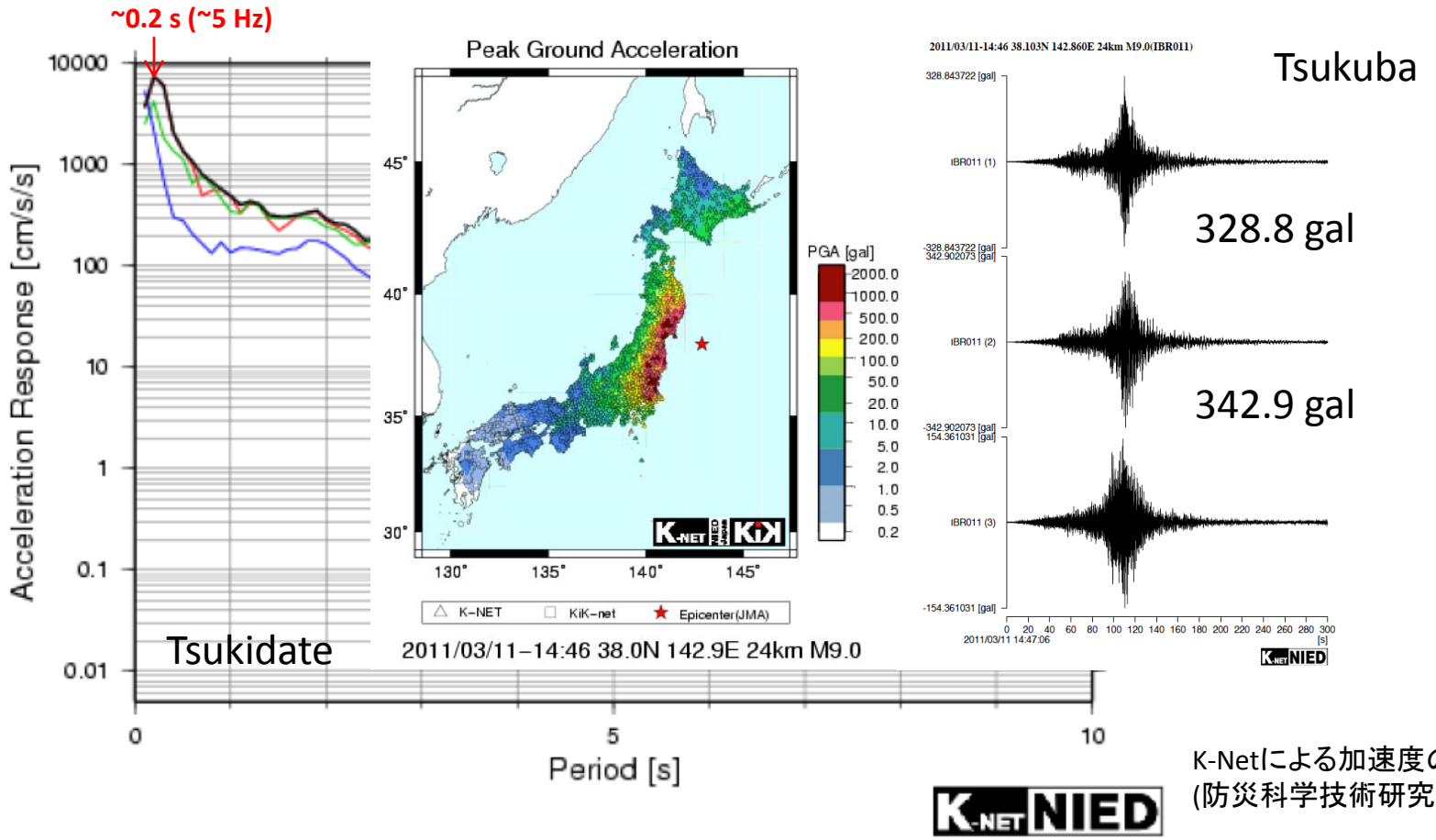
KEK e-/e+ Injector Group

2011. 3. 11

Earthquake Video.wmv

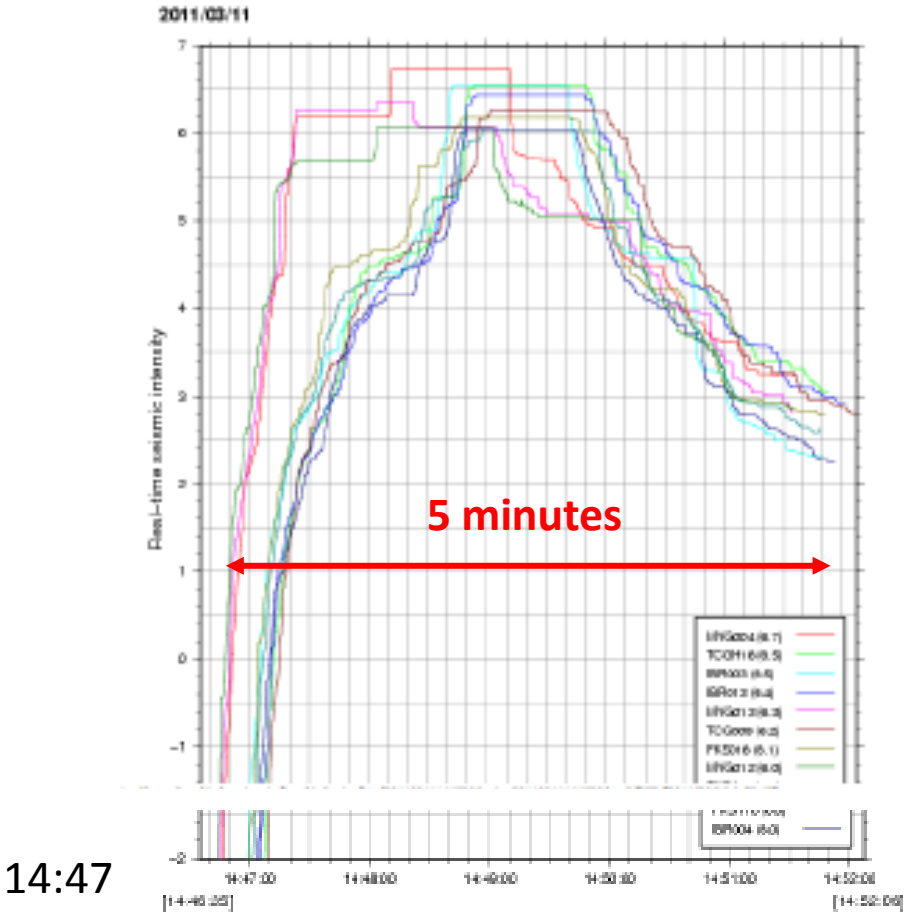
This is beginning of the earthquake.
It shook for nearly three minutes.
It was a long and strong earthquake we never experienced.

This is the beginning of the earthquake.
Long (~3 minutes) and strong (6 lower in Japanese scale) earthquake we never experienced!

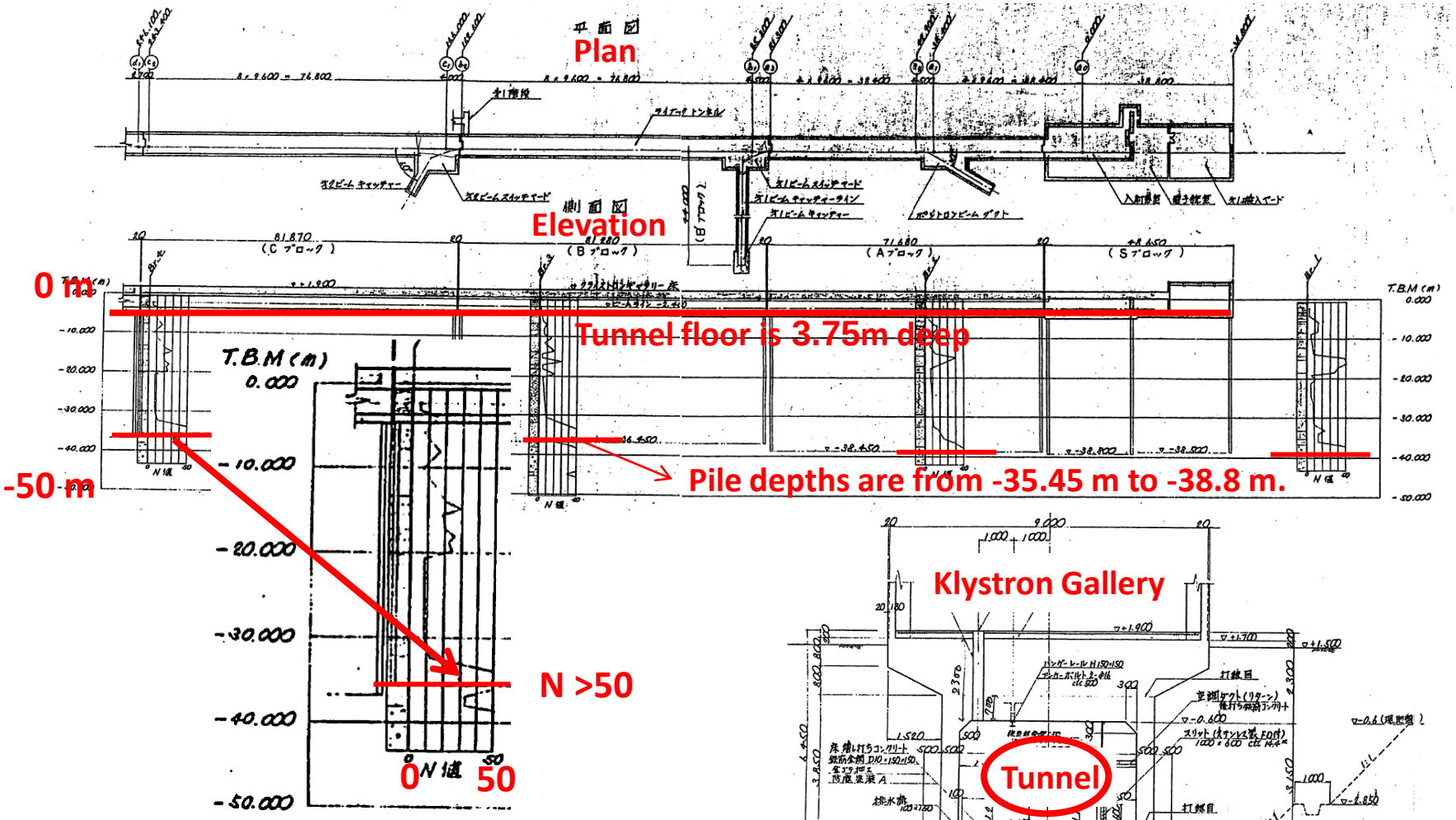


K-Netによる加速度の観測
(防災科学技術研究所提供)

This is the beginning of the earthquake.
Long (~3 minutes) and strong (6 lower in Japanese scale) earthquake we never experienced!

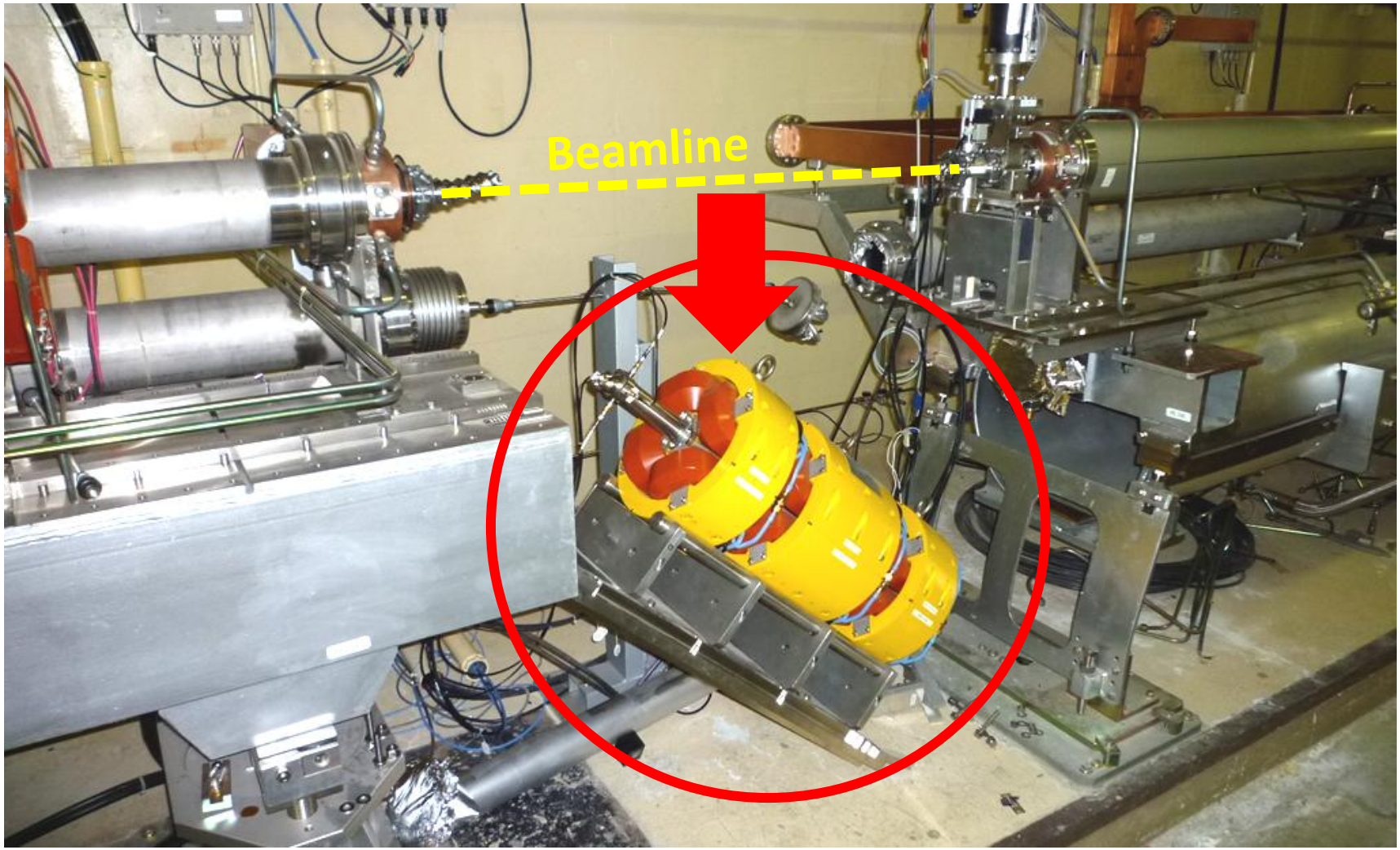


Damage of equipment in the 600-m long Tunnel

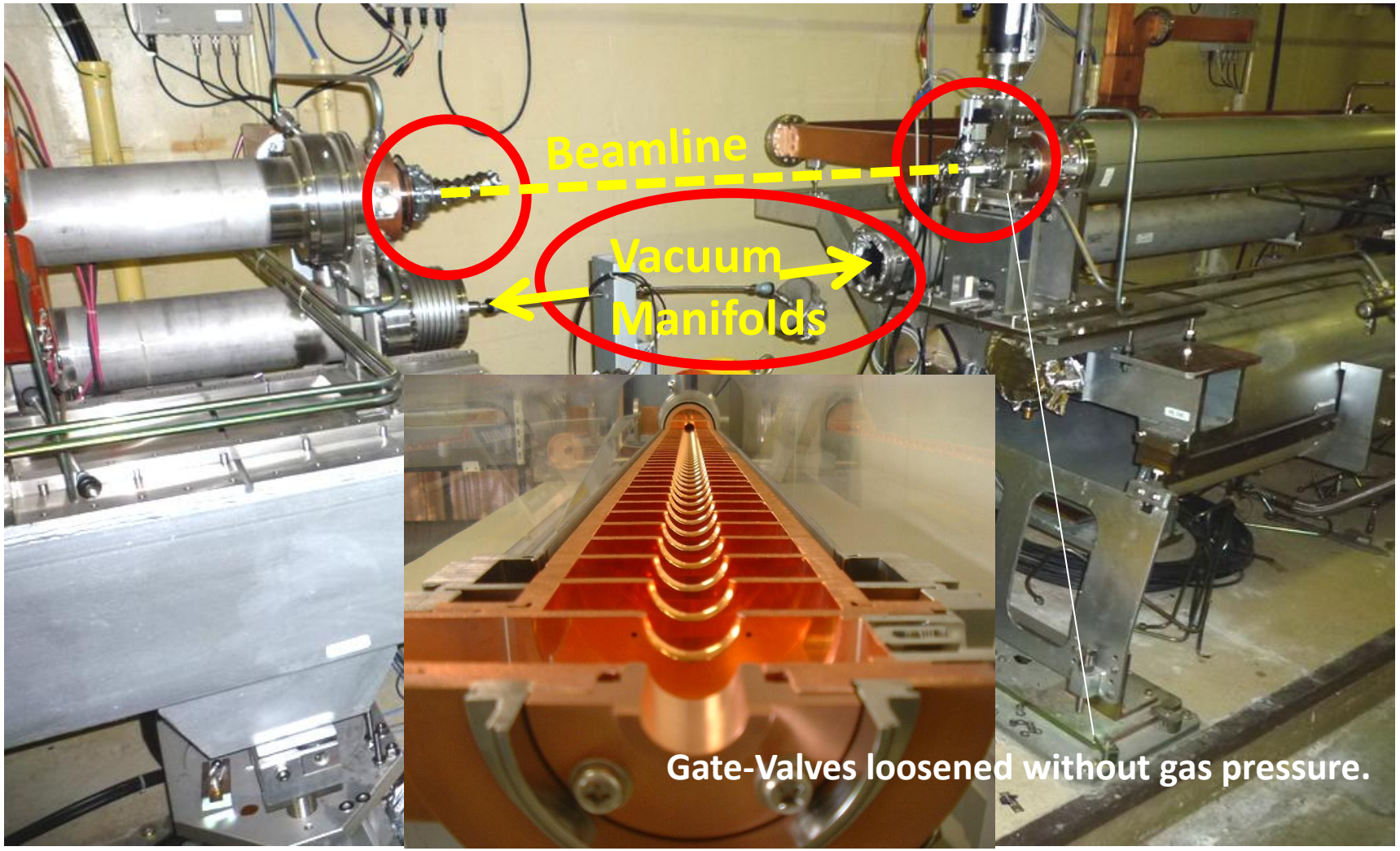


N value: hammering frequency when an iron rod penetrates the ground by 30 cm with free falls of a 63.5 kg hammer from 75 cm high.（N値：鉄管に重さ63.5kgのハンマーを75cmの高さから自由落下させて30cm地面に貫入するのに必要な打撃回数）

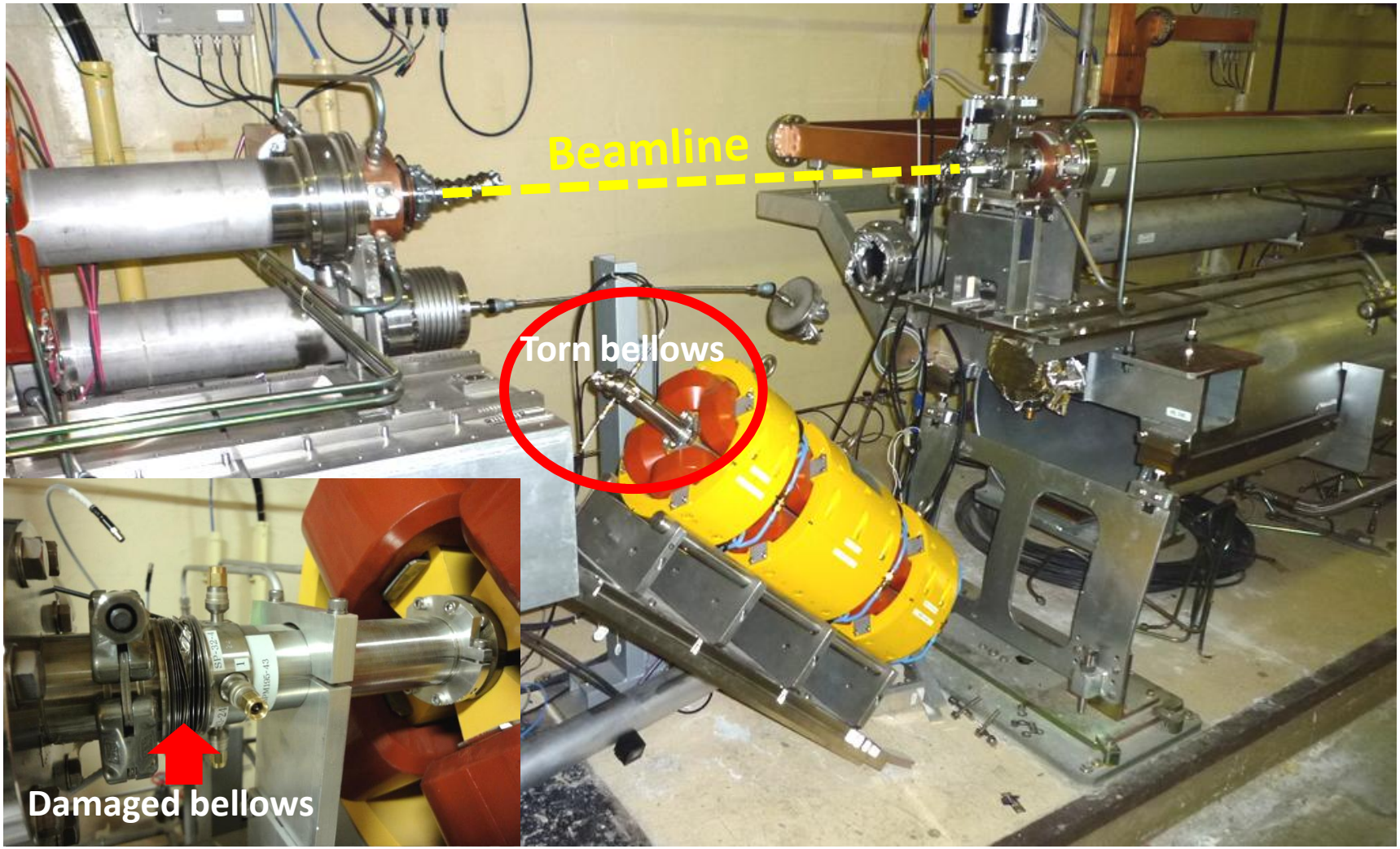
Drop-down of a Quadrupole Triplet



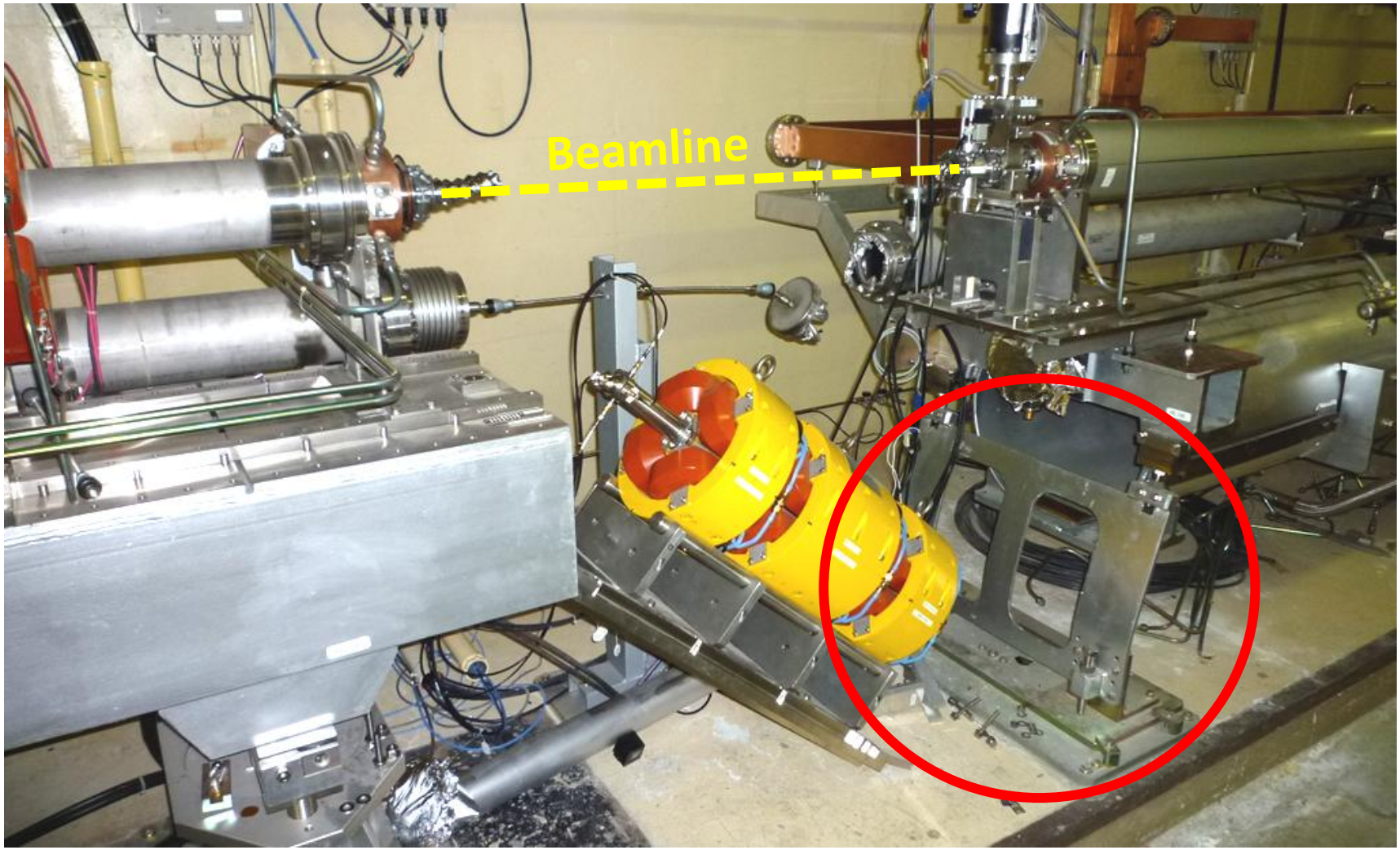
Break-down of the entire Linac Vacuum



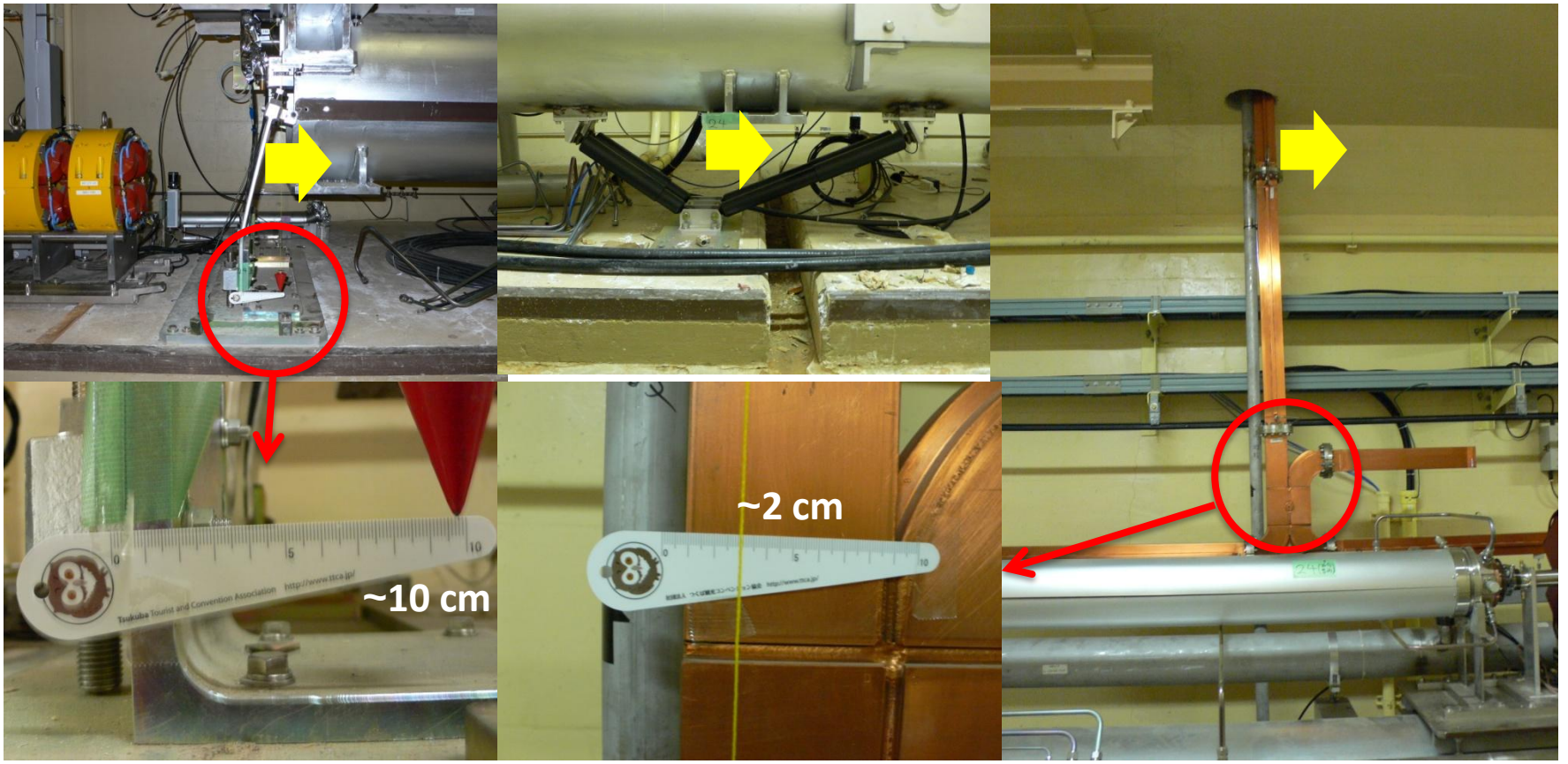
Destroyed BPMs



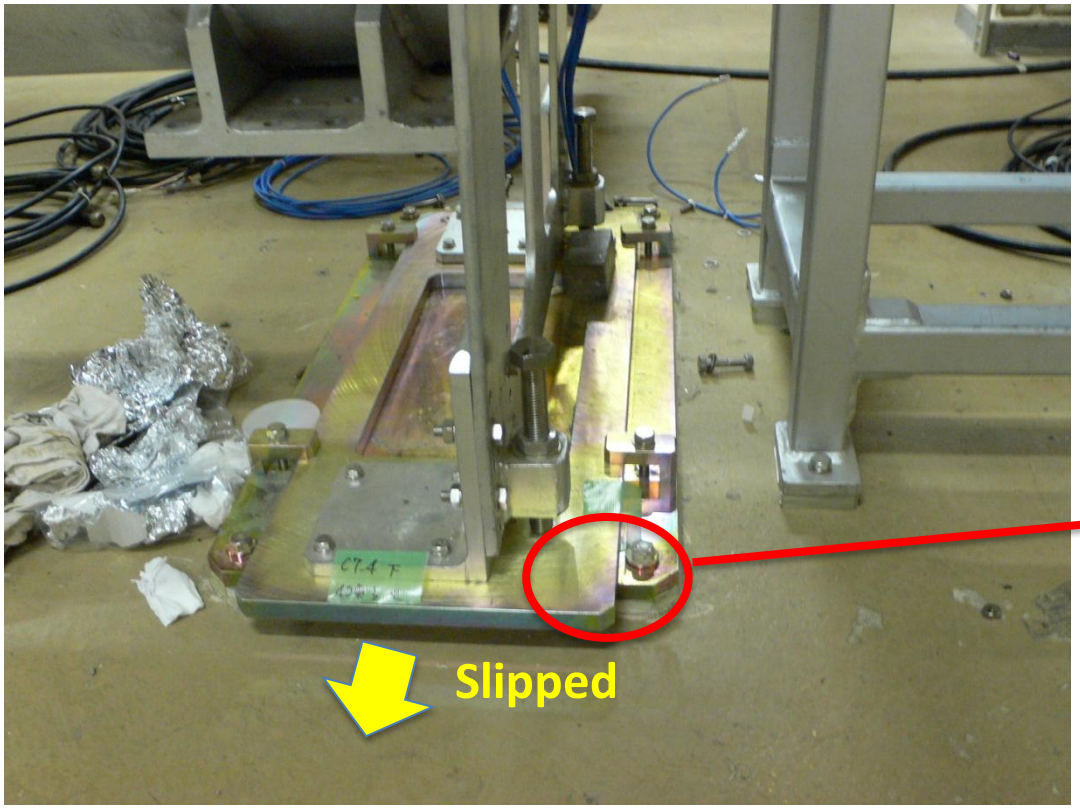
Destroyed Girders

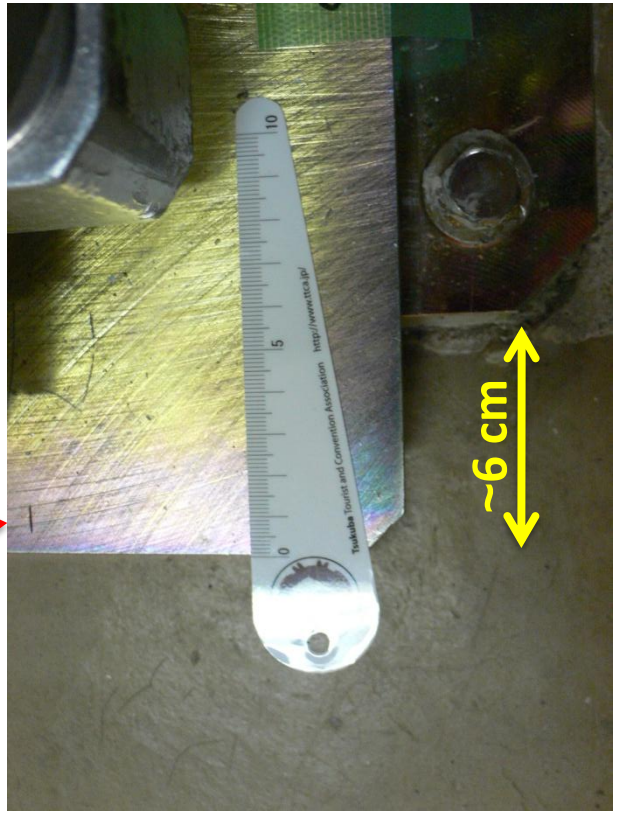


Longitudinal Shifts of the Accelerator

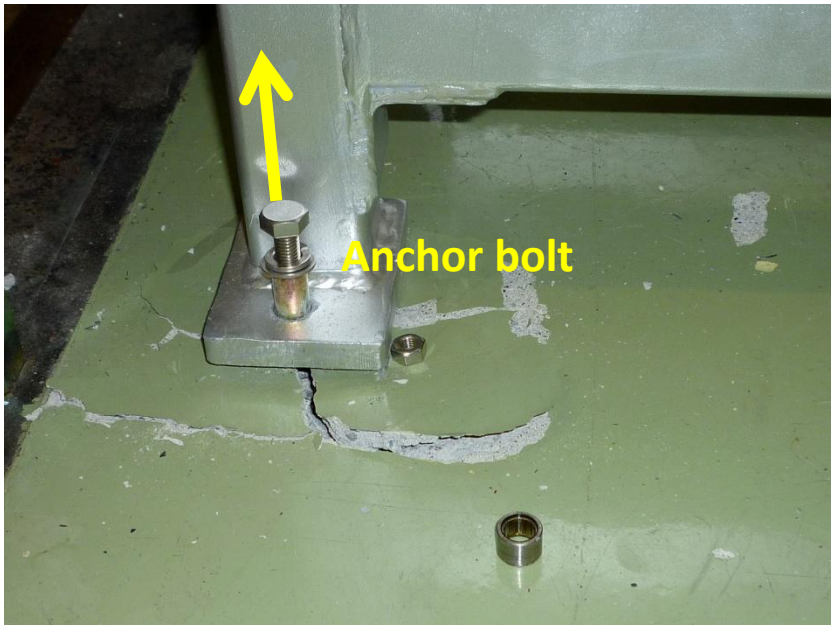


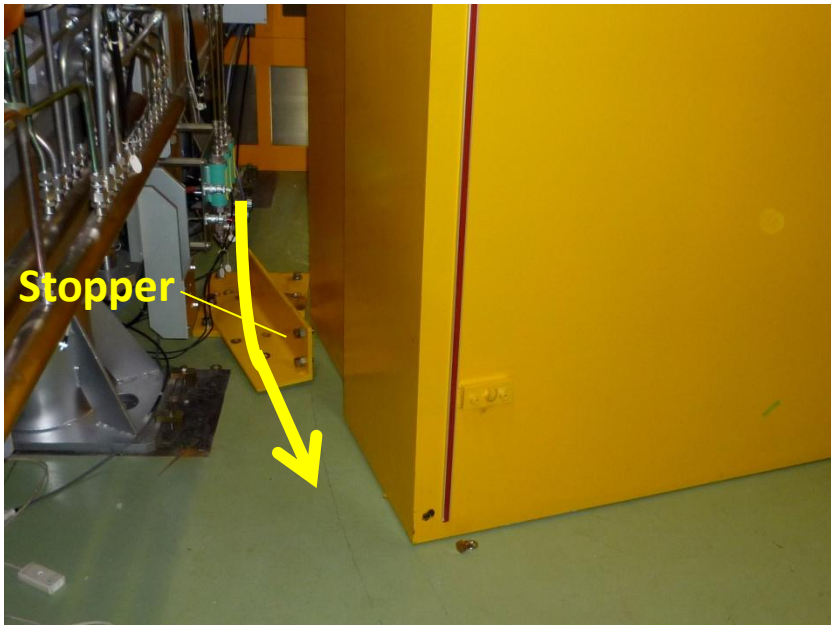
Transverse Shifts





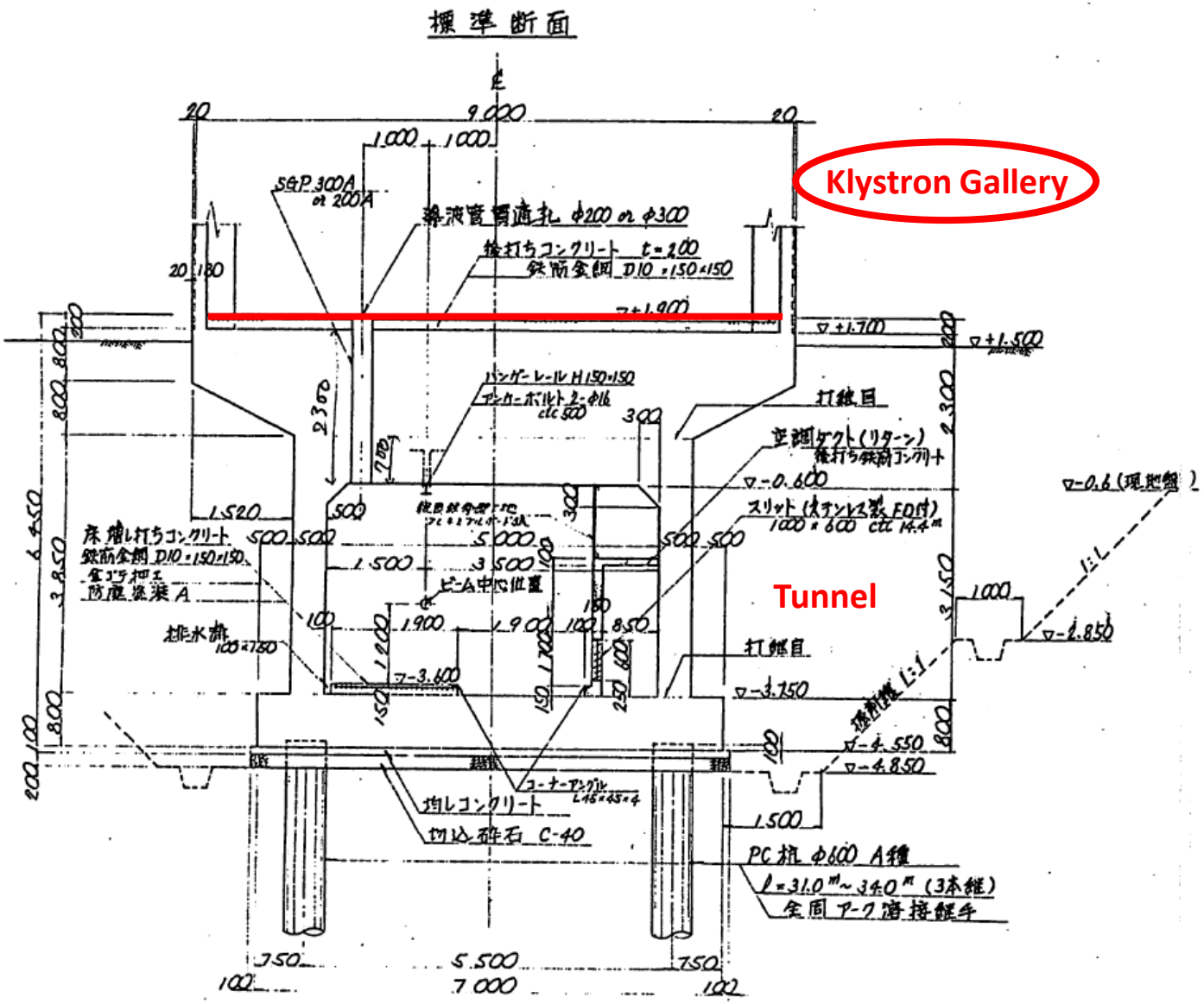
Incredible Destructive Force



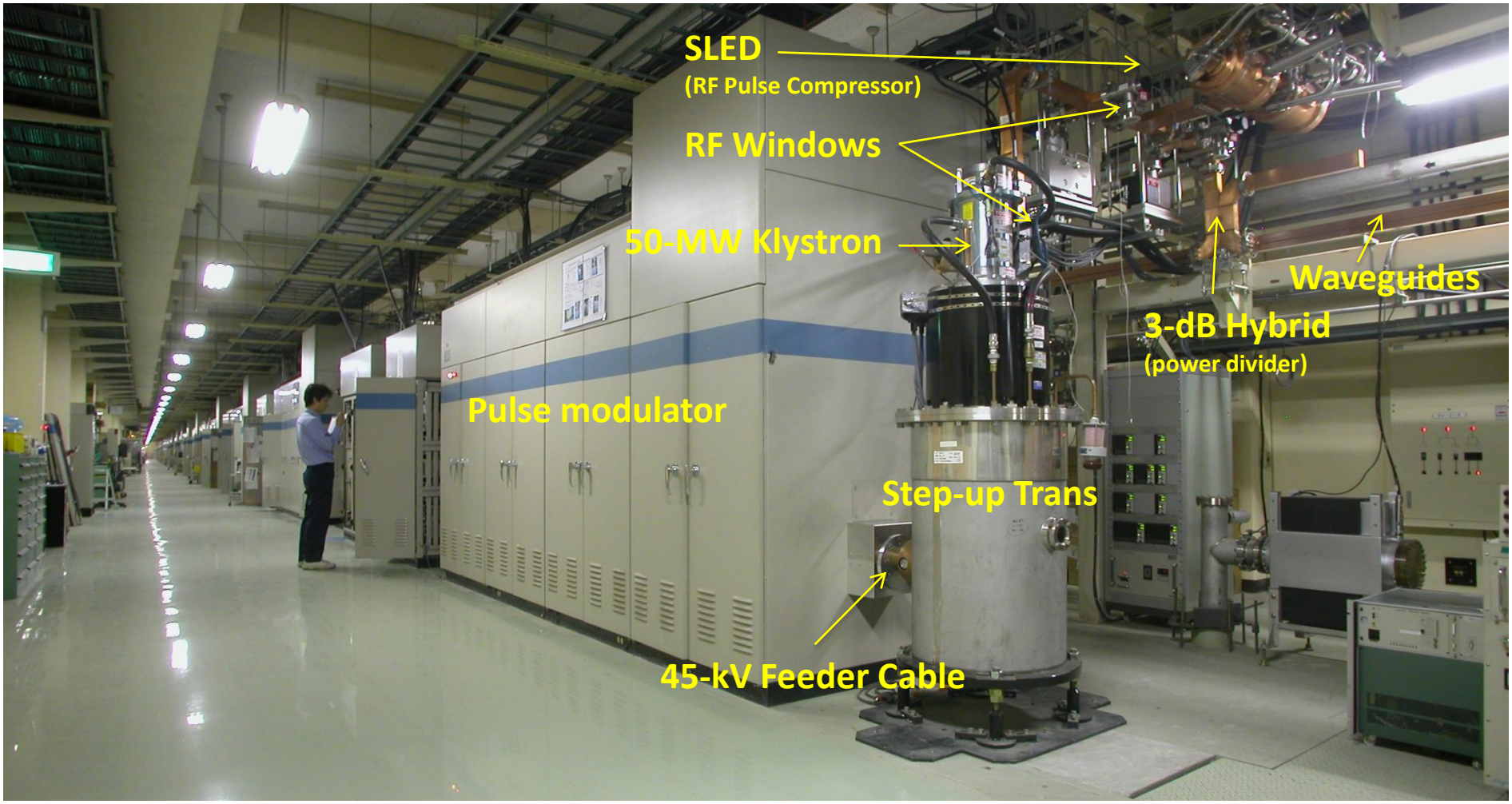


Inflow Water through Tunnel Joints

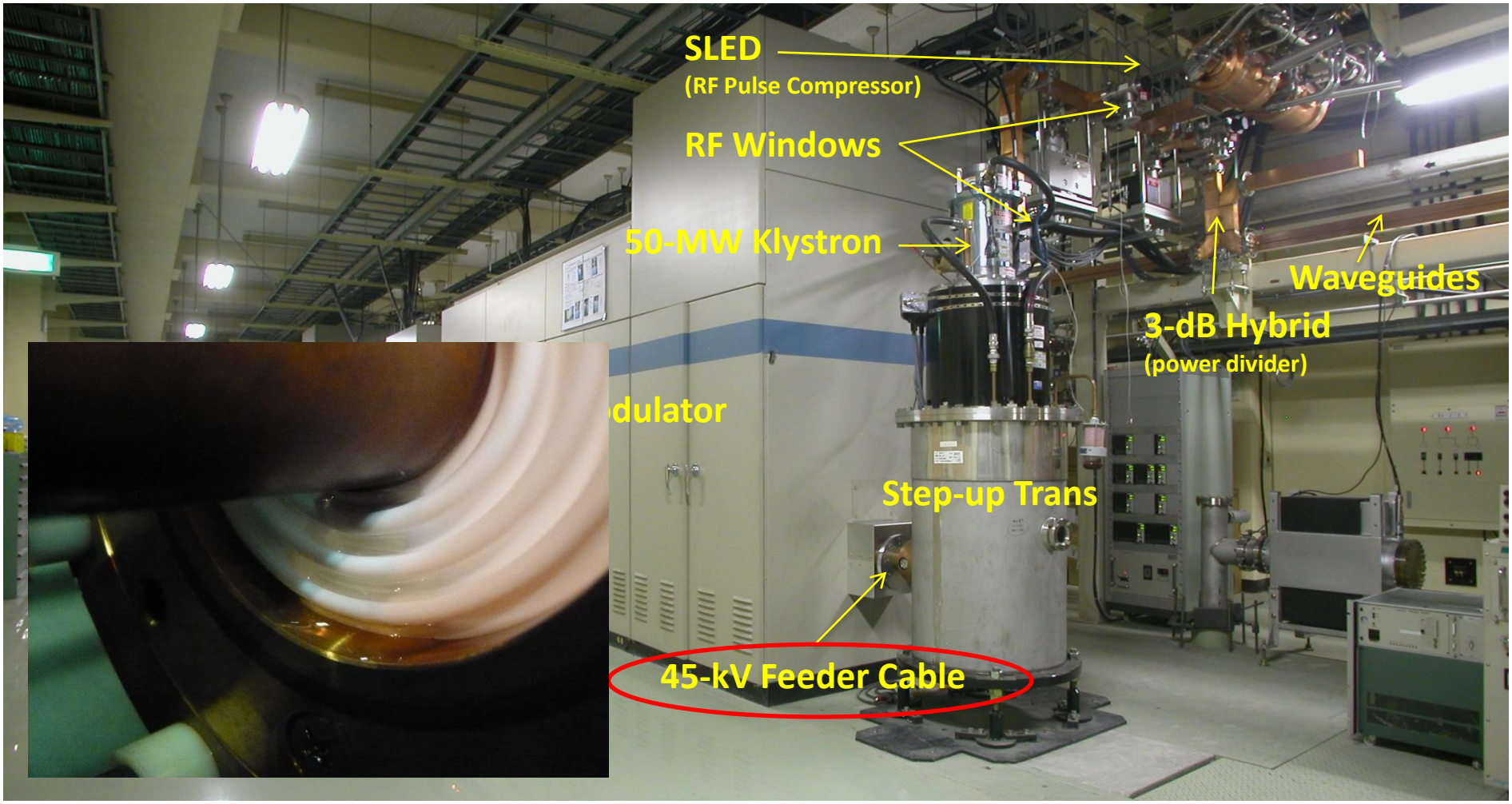
Damage of equipment in the Klystron Gallery



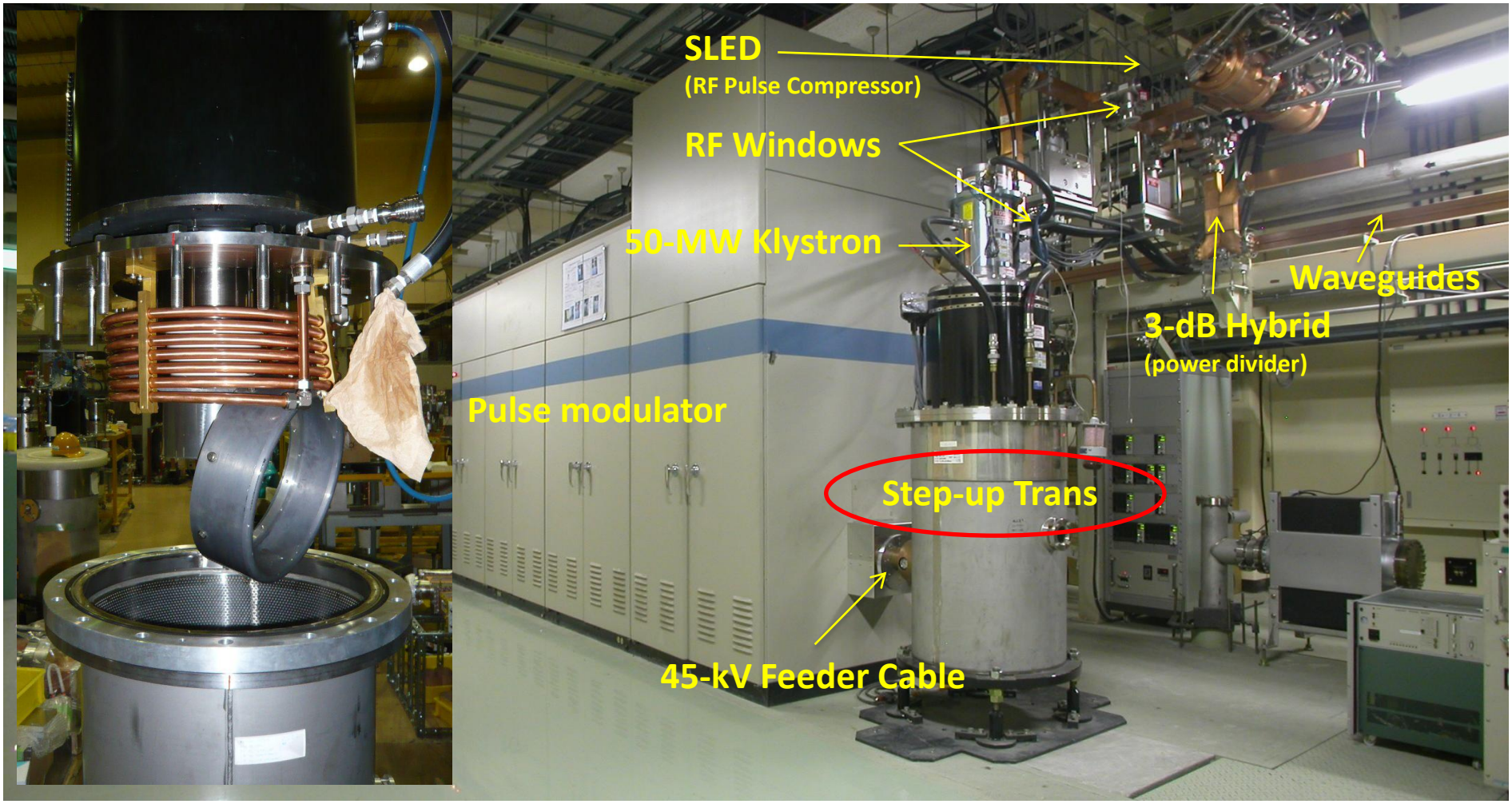
We have ~60 RF Units



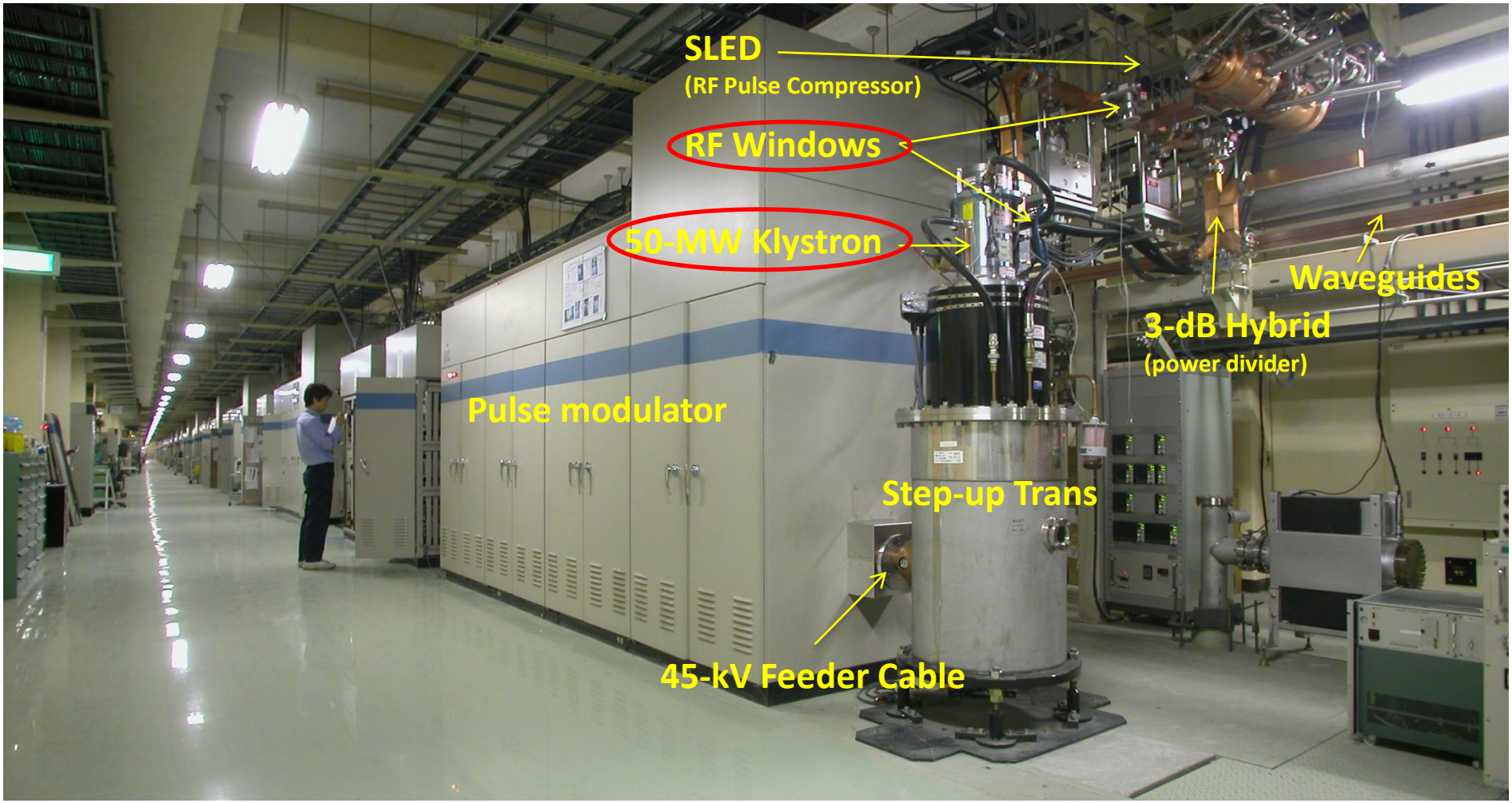
45-kV Pulse Feeder cable



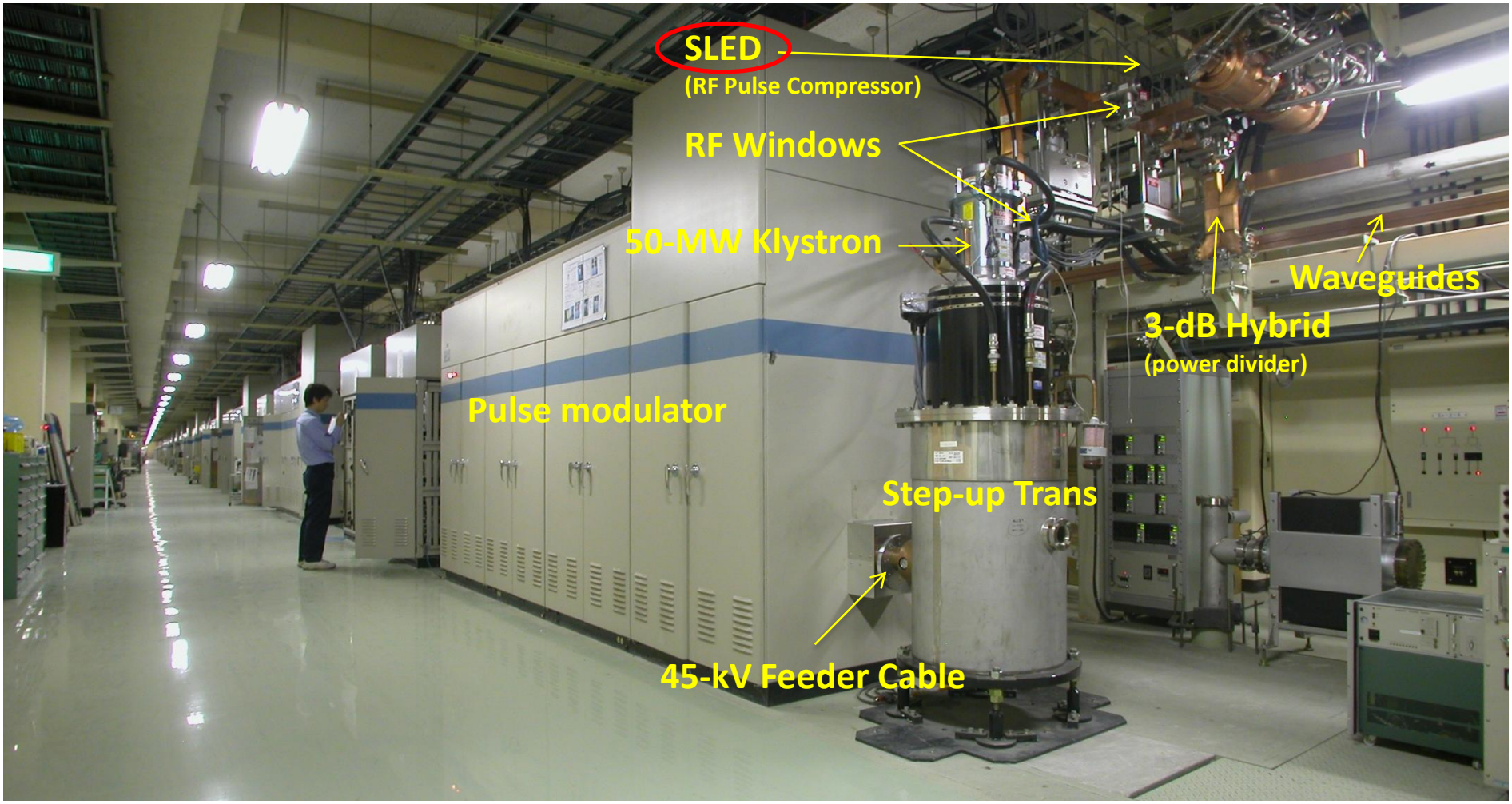
45-kV Pulse Feeder cable



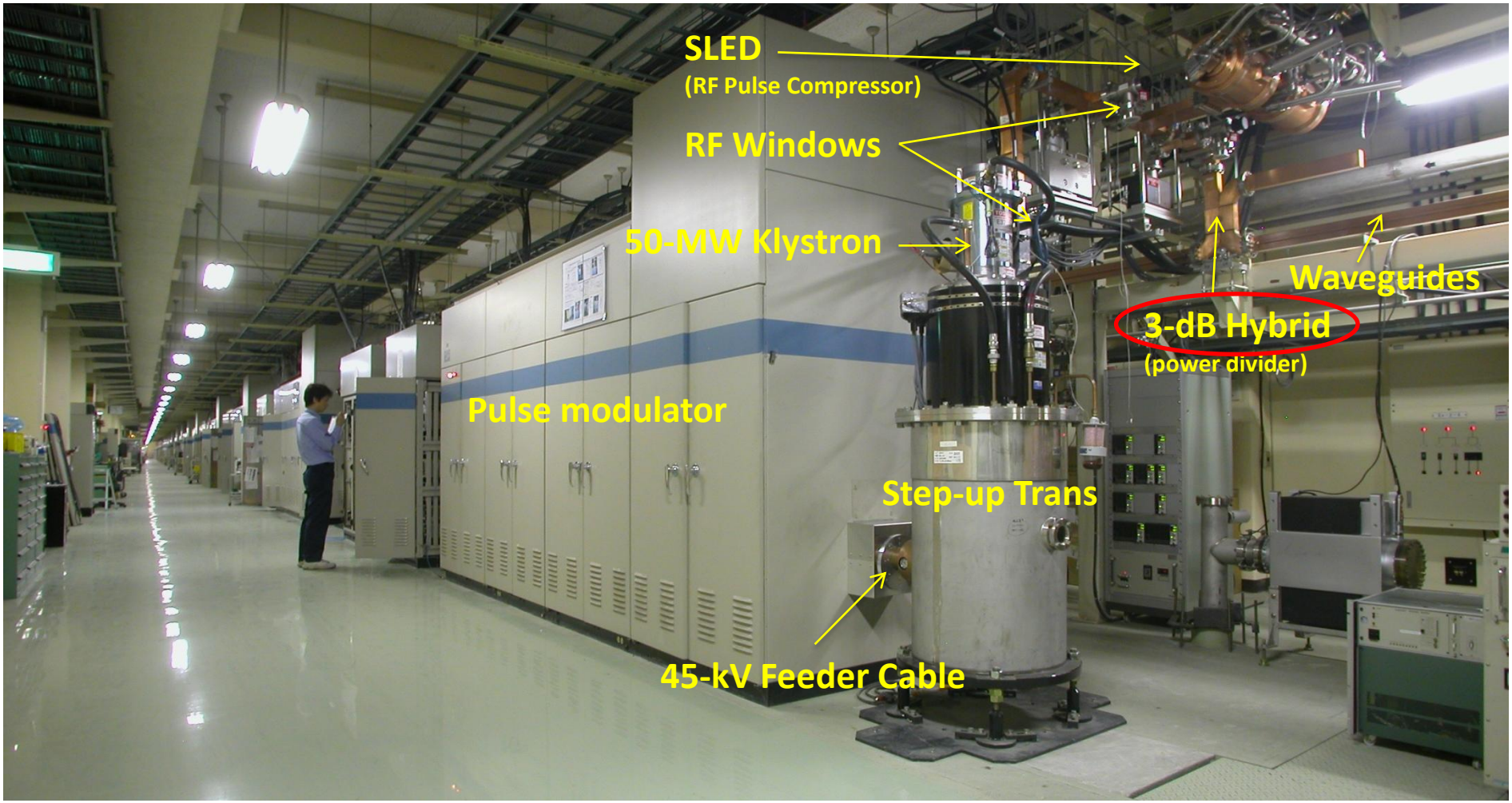
45-kV Pulse Feeder cable



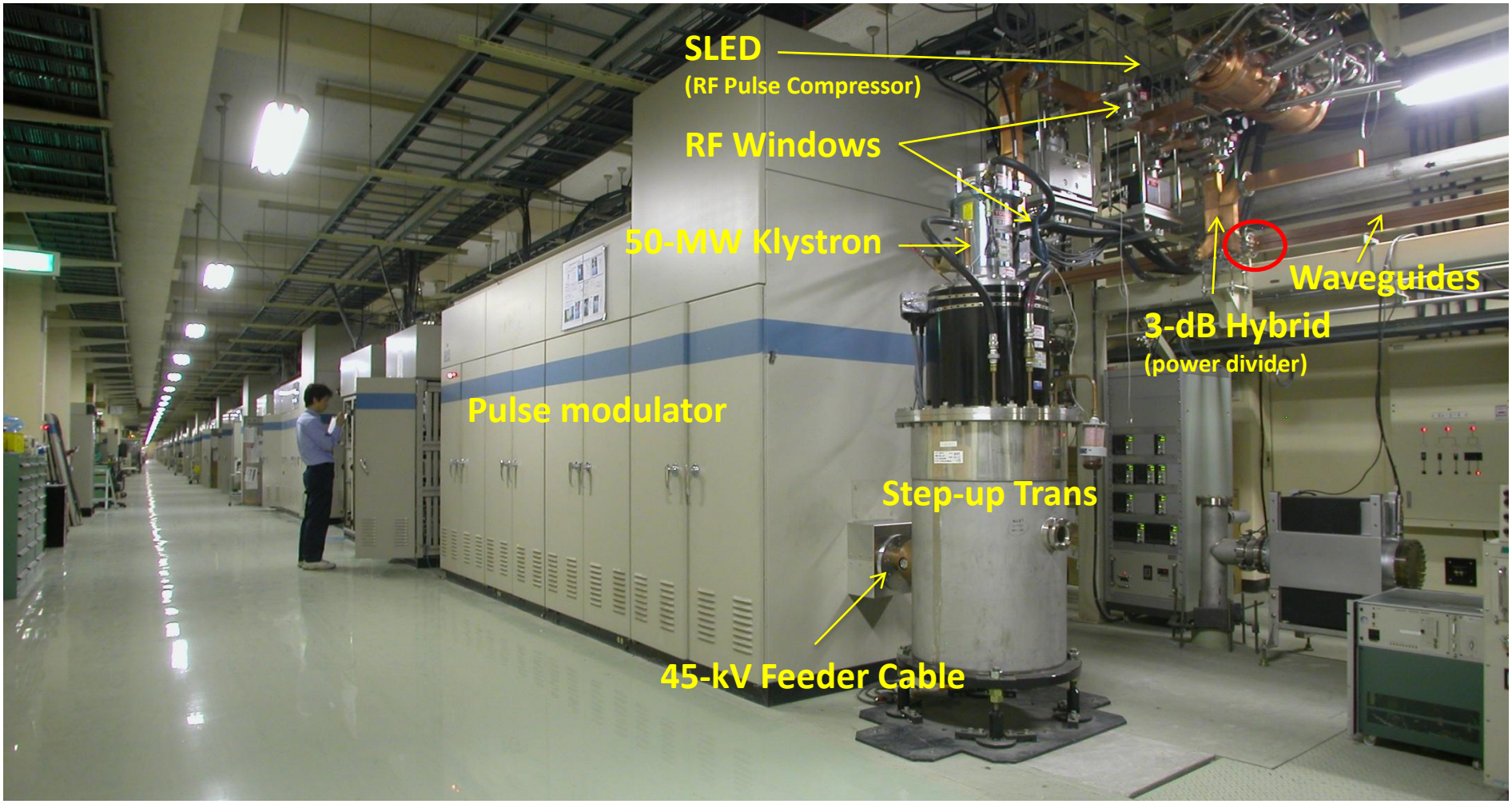
45-kV Pulse Feeder cable



45-kV Pulse Feeder cable



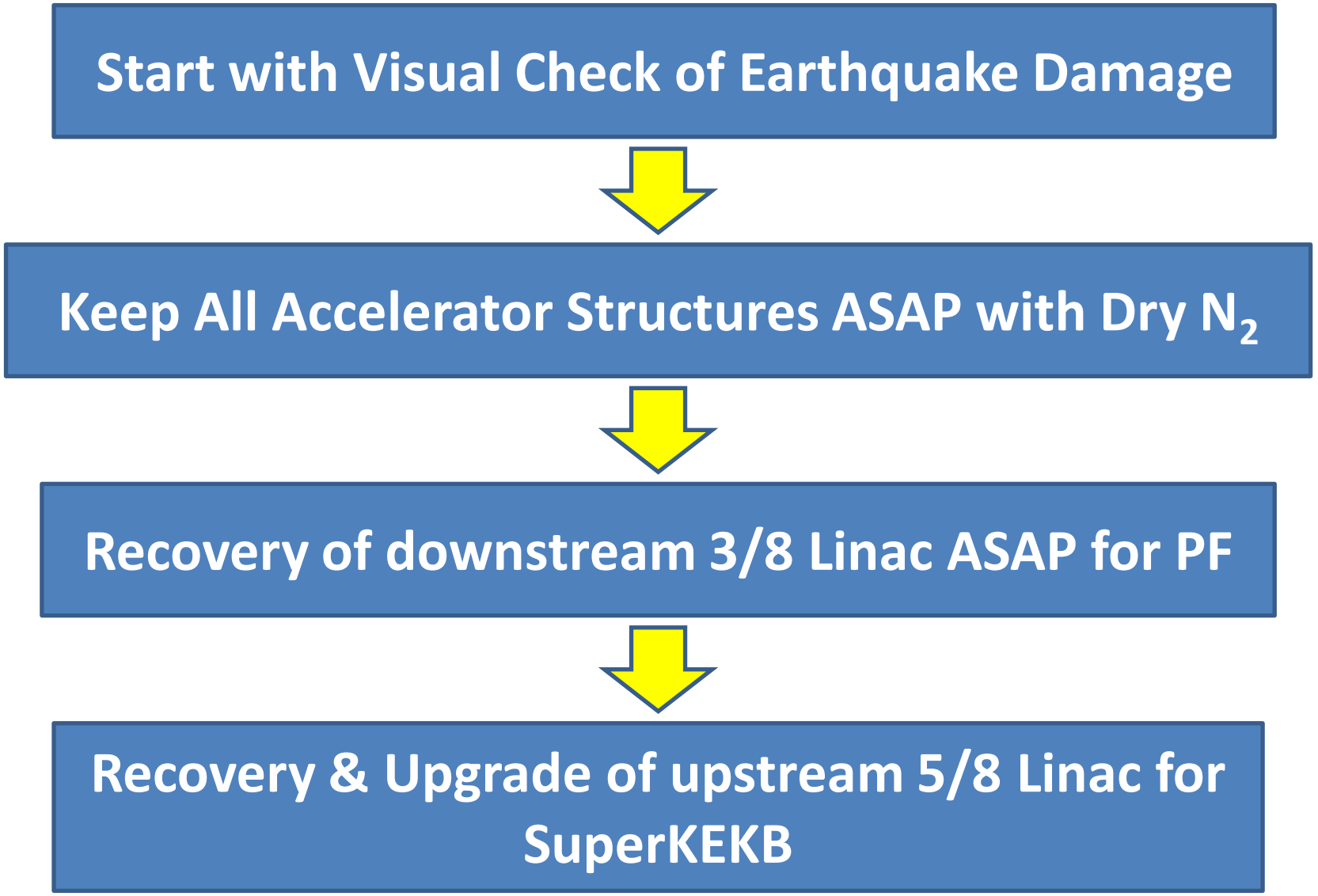
45-kV Pulse Feeder cable



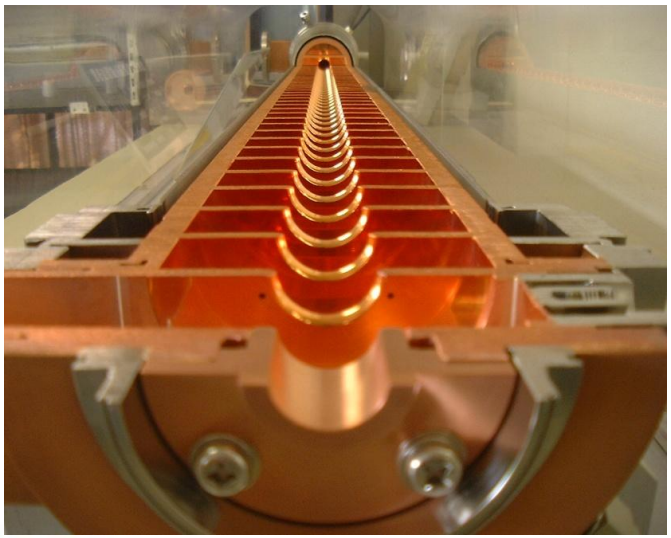
Damage of equipment in the Klystron Gallery

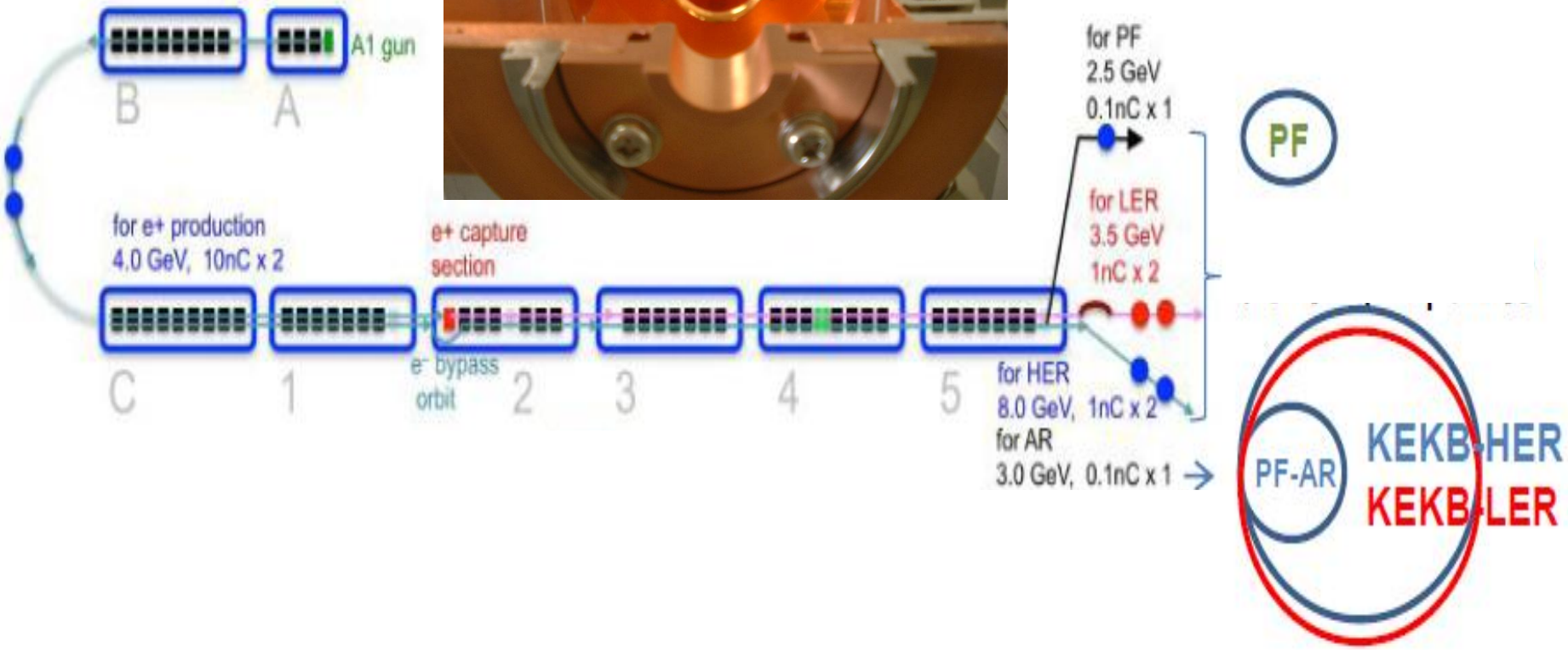
Recovery of Linac

Discuss how we should address this Disaster!

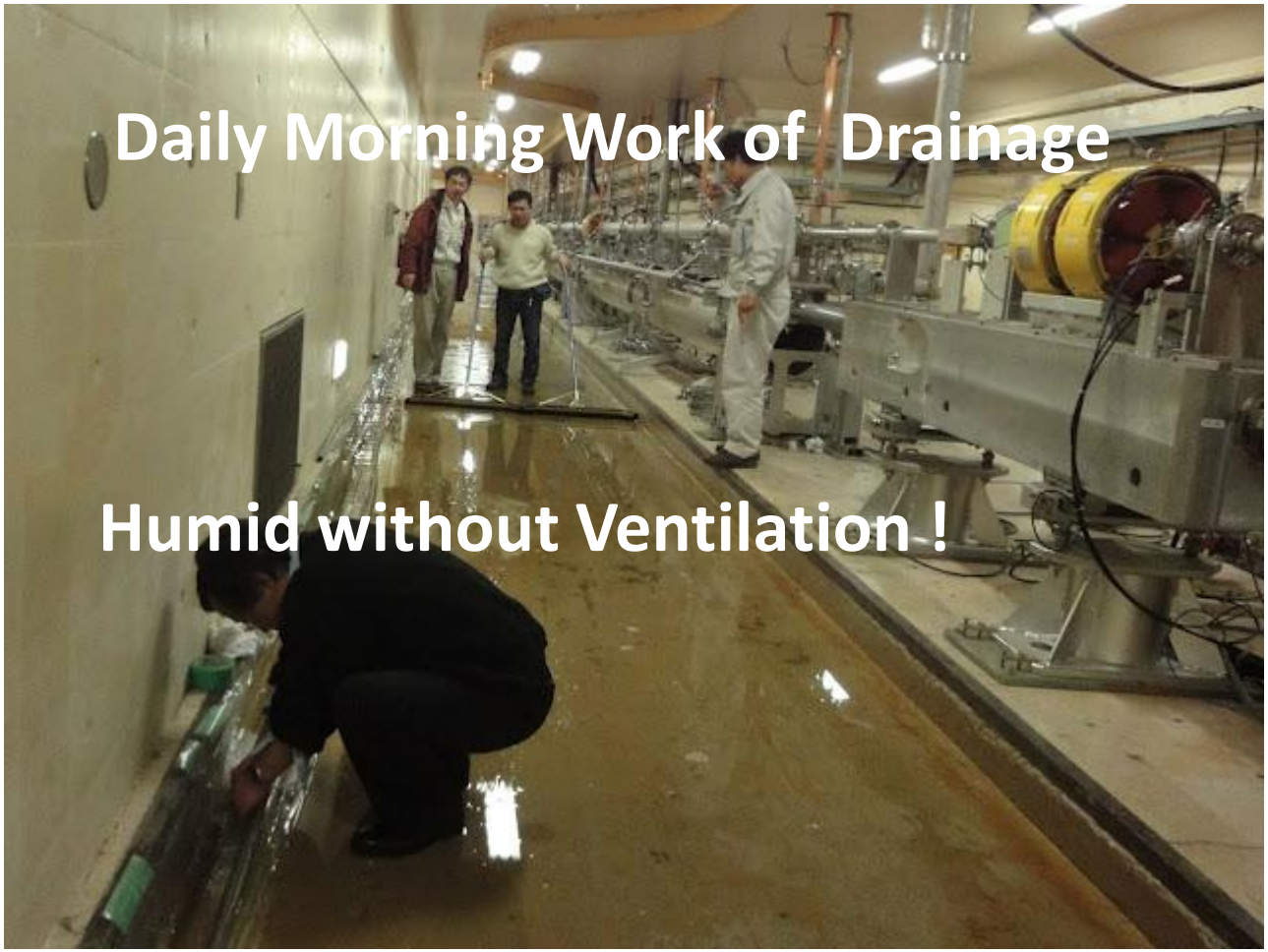

Start with Visual Check of Earthquake Damage
Keep All Accelerator Structures ASAP with Dry N_2
Recovery of downstream 3/8 Linac ASAP for PF
Recovery & Upgrade of upstream 5/8 Linac for SuperKEKB

We have ~60 RF units.
Keep All Accelerator Structures ASAP with Dry N_2 !



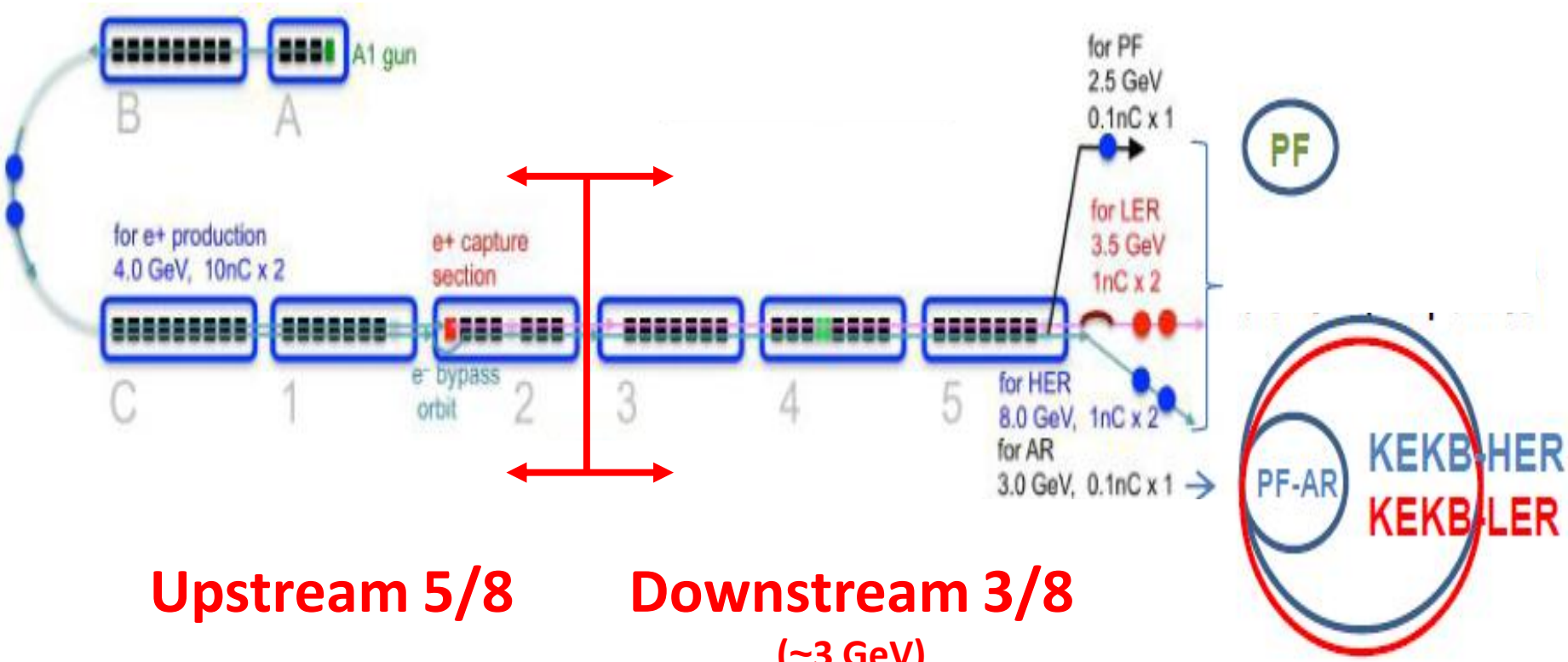


Bad Atmosphere before April 25



Dry N_2 Purge done after 2 weeks

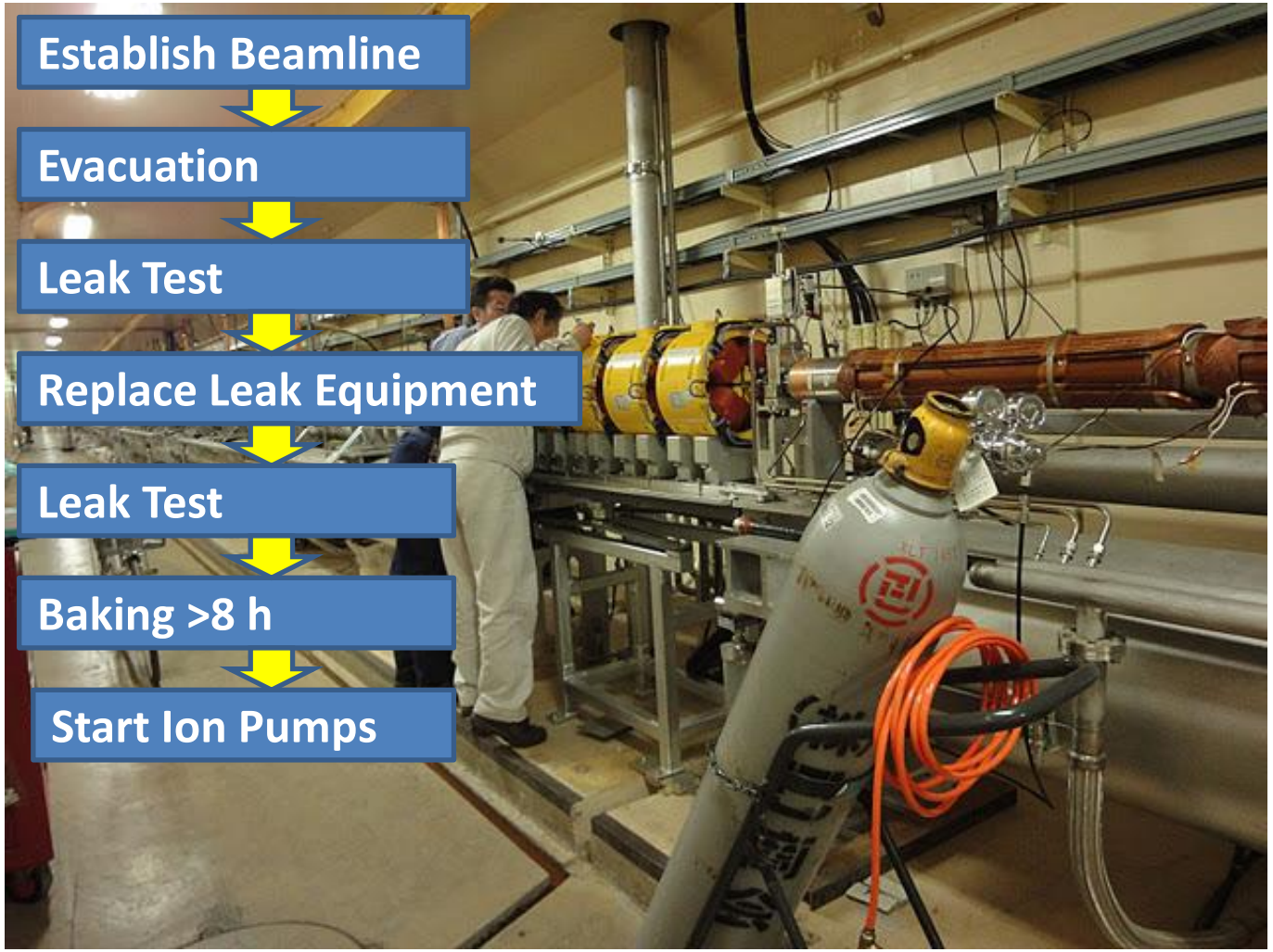
“Recovering 3/8” Started on March 28



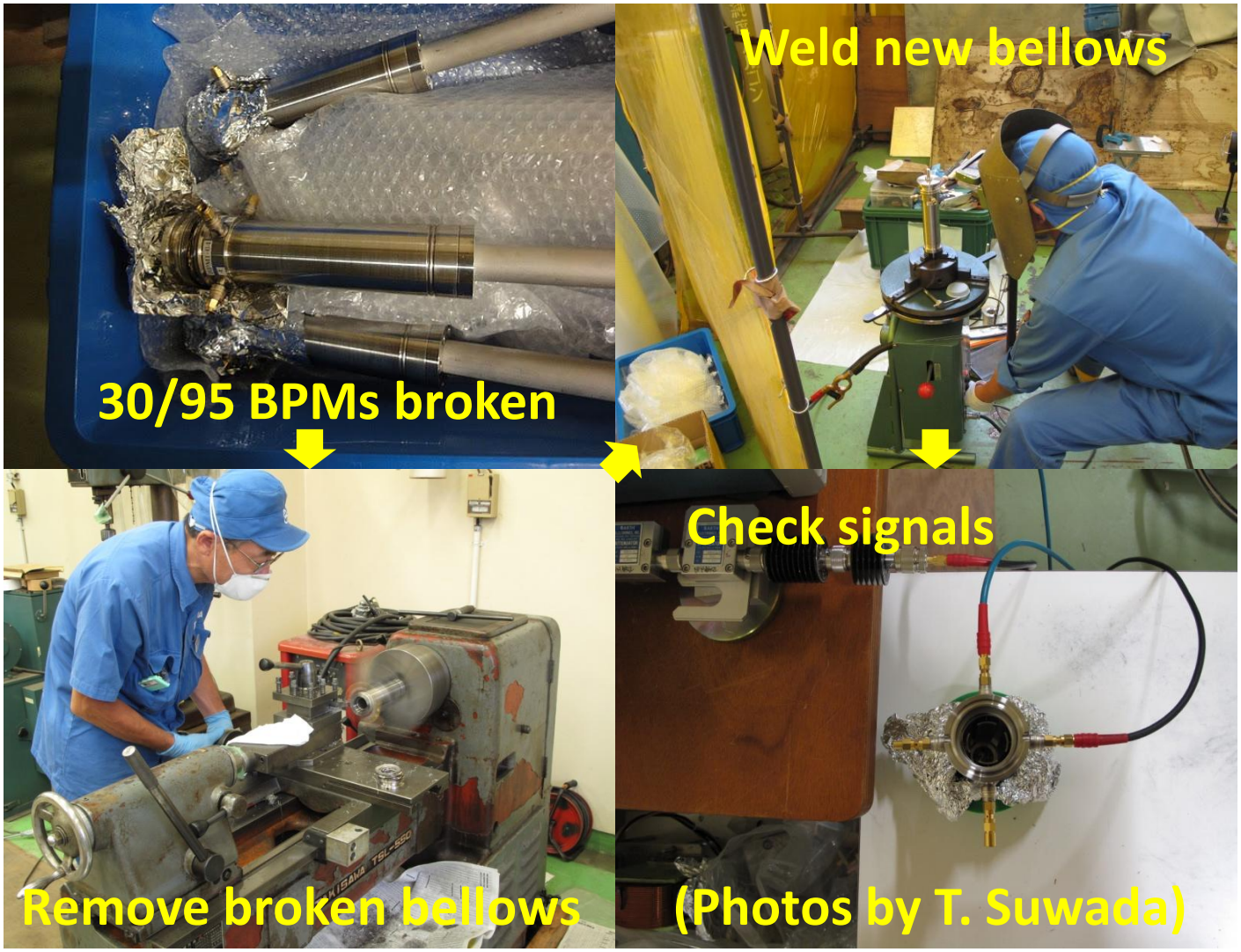
Upstream 5/8 **Downstream 3/8**

(~3 GeV)

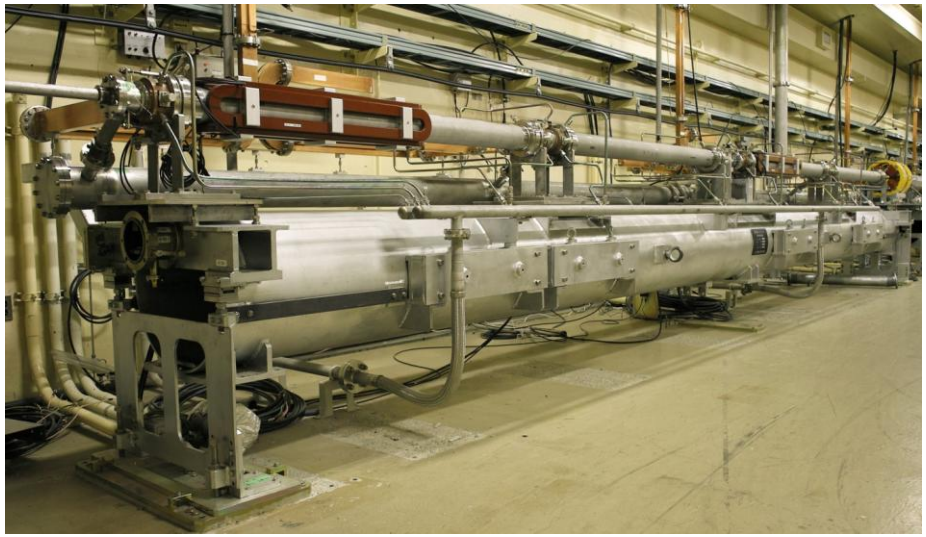
3/8 Vacuum Recovery Needed 1 month



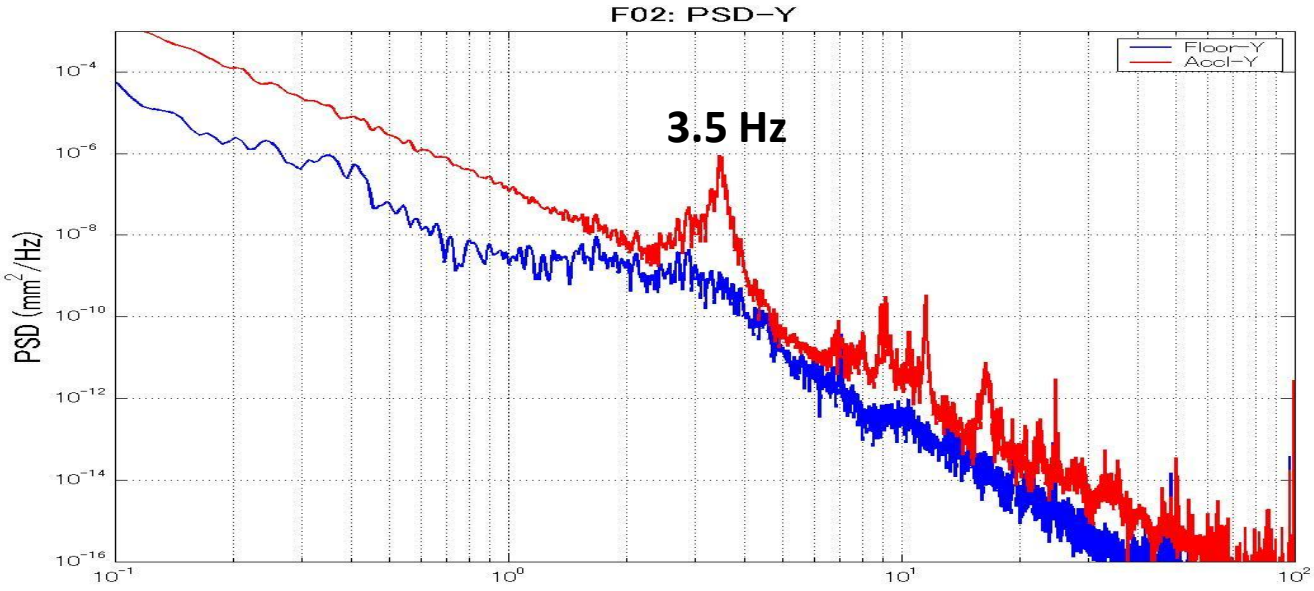
BPMs Repaired in KEK Workshop



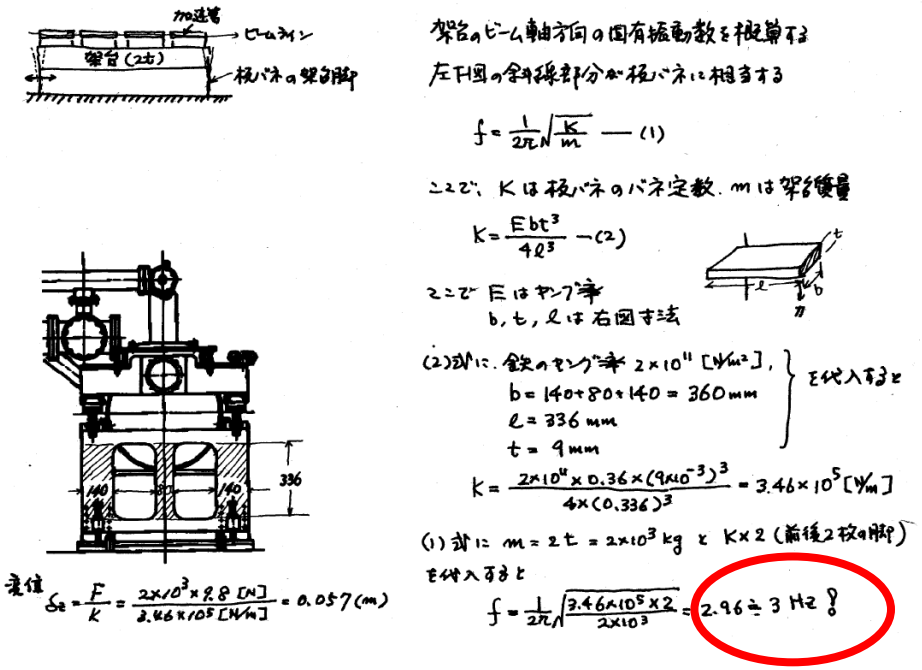
Oscillation Analysis

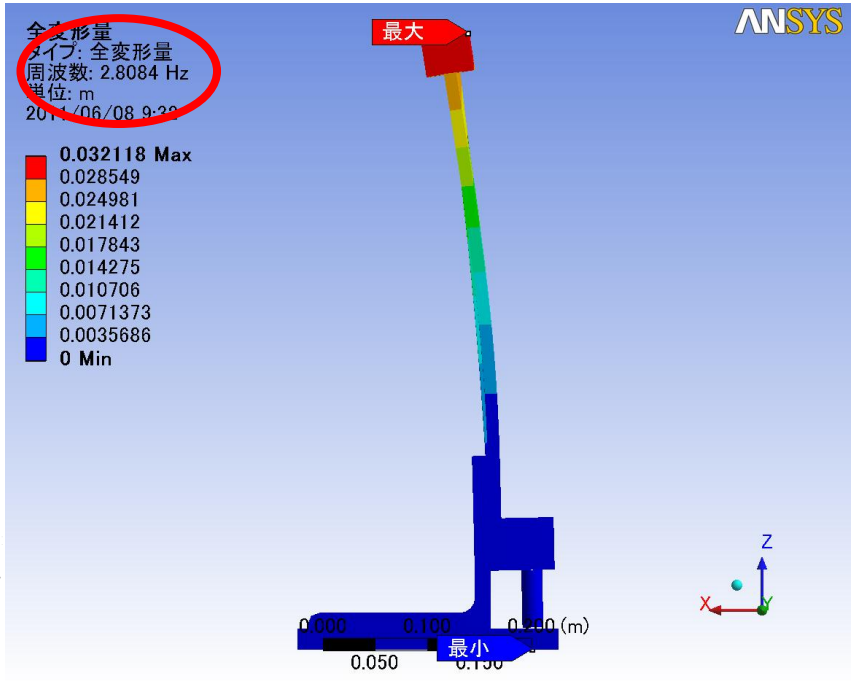


(Data by R. Sugahara)



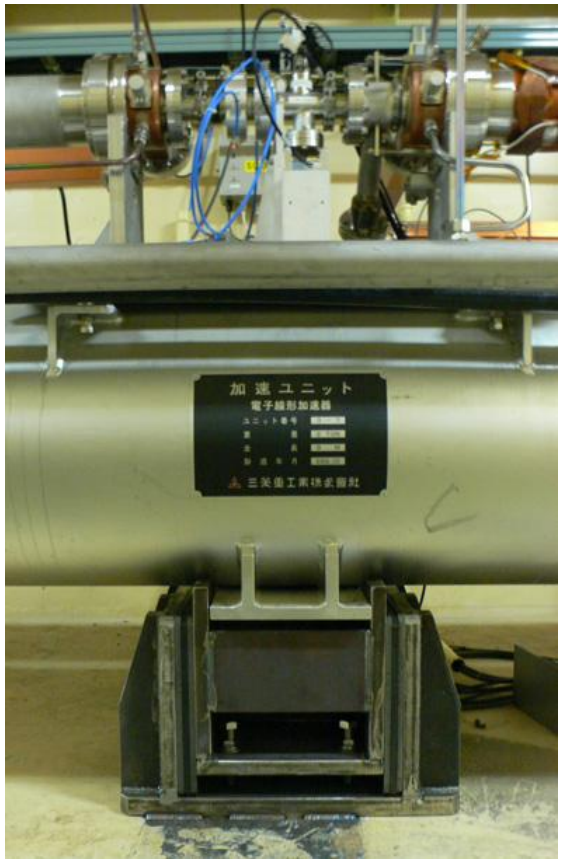
Oscillation Analysis





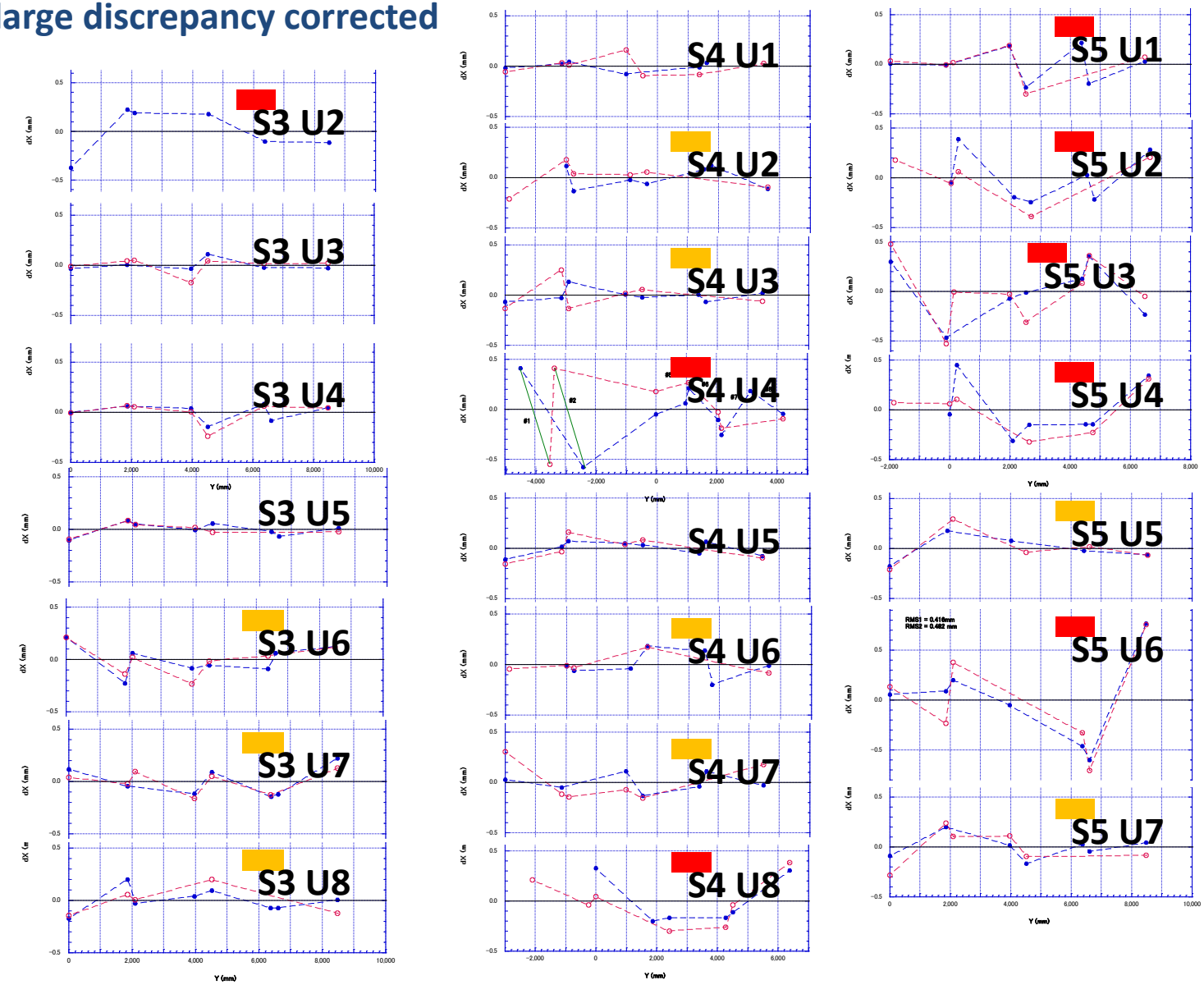
(by K. Kakihara)

Reinforced Accelerator Girders
Against expected strong aftershocks



Survey and Alignment

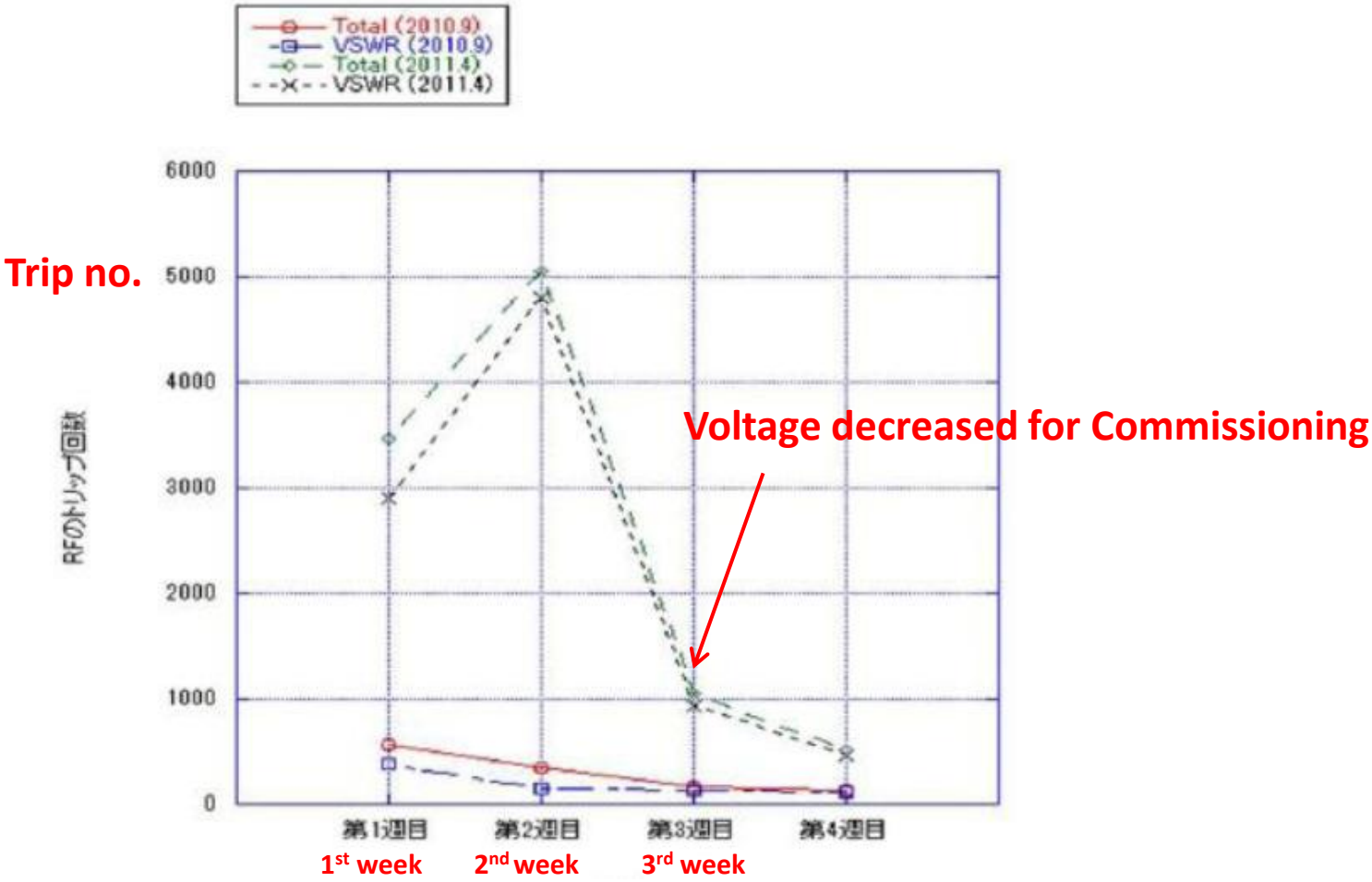
Only large discrepancy corrected



(Data by R. Sugahara and H. Iinuma)

The rack was re-installed

RF Conditioning

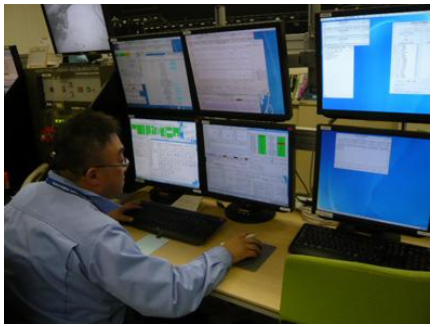


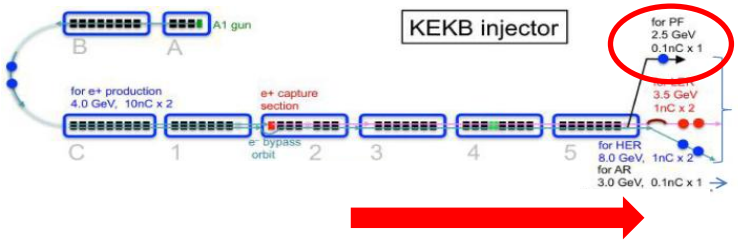
(Data by Y. Yano)

Summary of the recovery process from Earthquake to Linac commissioning

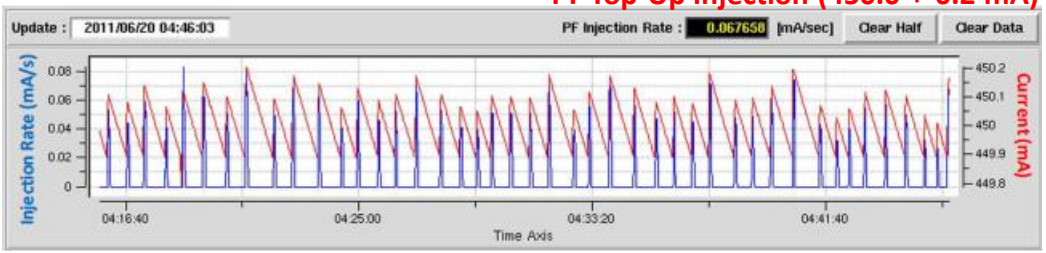
Action / Week	Work			Requirement		
	Tunnel	Gallery	Others	Electric	Mechanic	Building
March 14 -	Visual Chk, N2-purge	Visual Check	Visual Check	20 kW		
21 -	N2-purge	Kly/ Thy	PPS	20 kW		
28-	Vacuum	Kly rplc.		60 kW		Crane
April 04 -	Vacuum	Kly rplc.		75 kW		
11-	Vacuum	Diode Test	Trigger Sys	90kW 2 MW night	Water (kly) Gas	
18-	Vacuum			90 kW		
25-		RF aging (Apr28-)		2 MW	Water (Sec3-5), Air	
May 02-		RF aging		2 MW		
10-		Cmmssn.		2 MW		

Injection to PF resumed ~2 months after the Earthquake





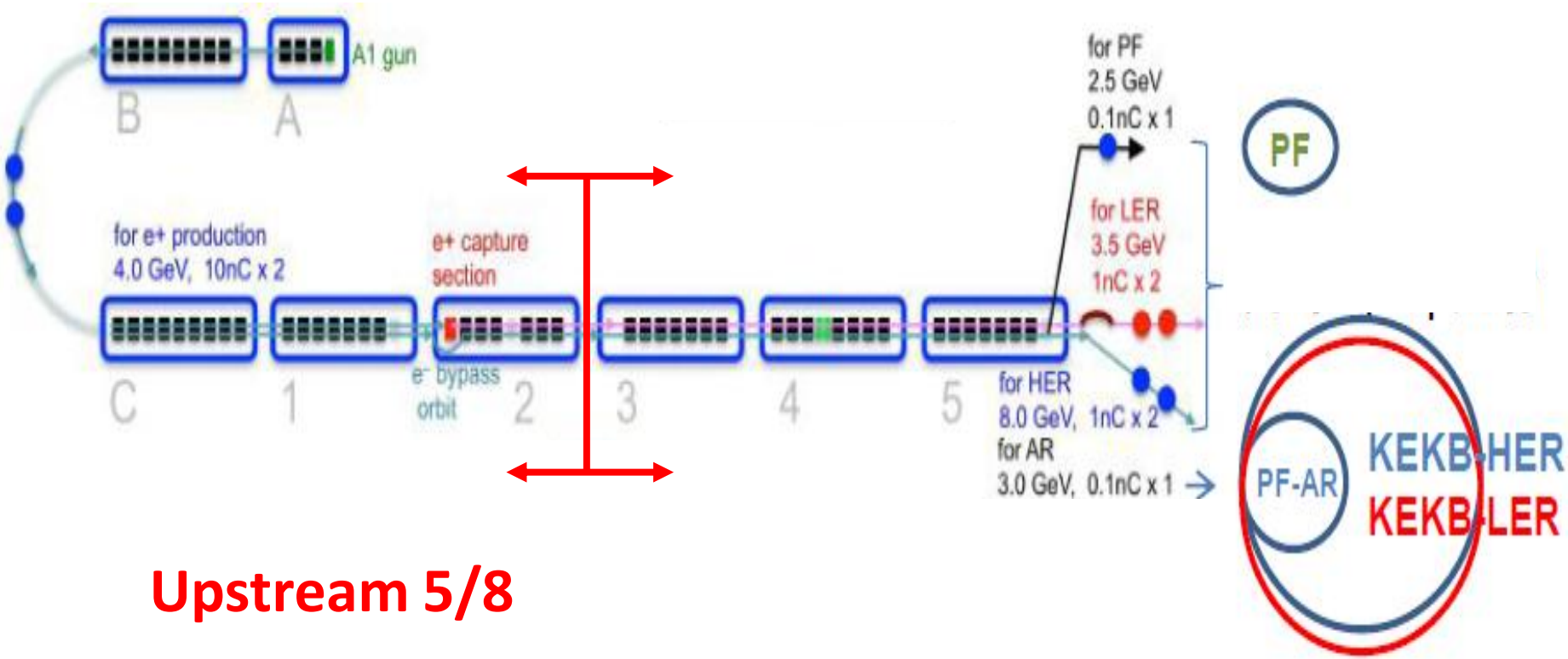
PF Top-Up Injection (450.0 +-0.2 mA)



On May 16 injection started for PF, June 1 for PF-AR.

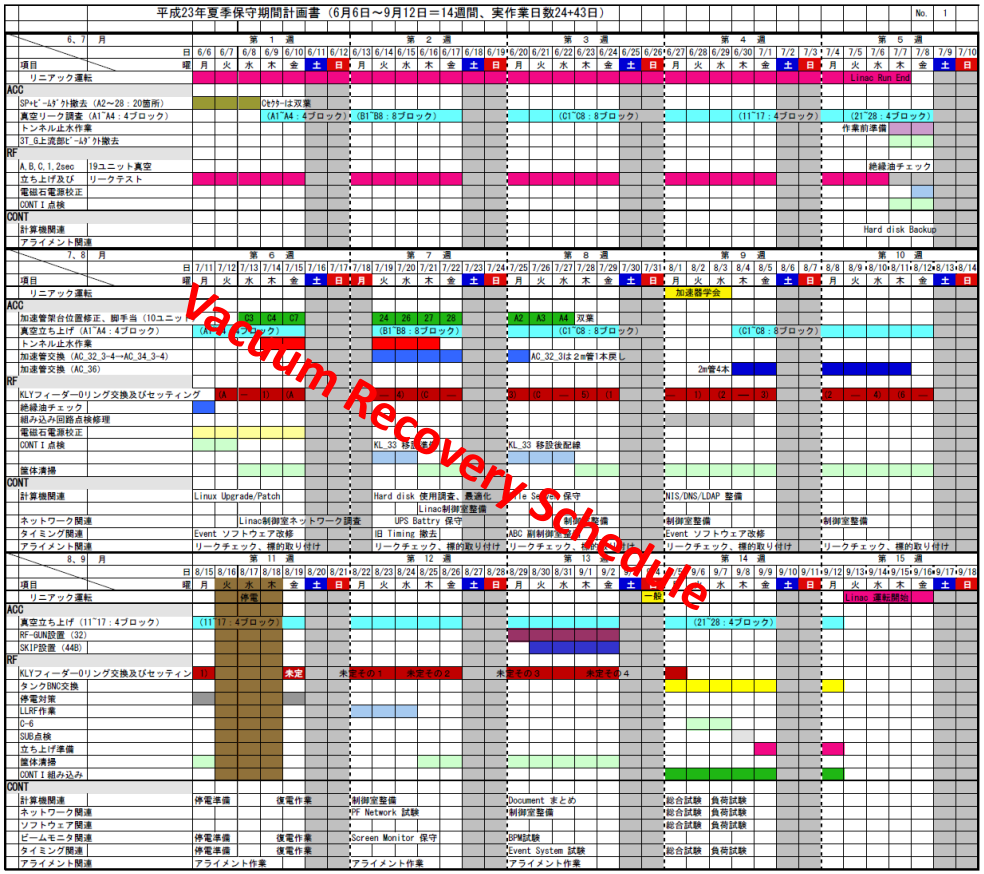
Recovery and Upgrade of the Linac

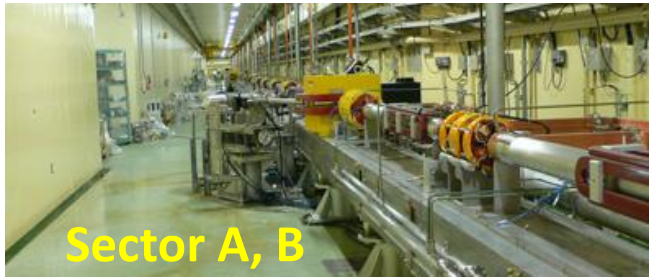
“Recovering 5/8” Started on June



Upstream 5/8

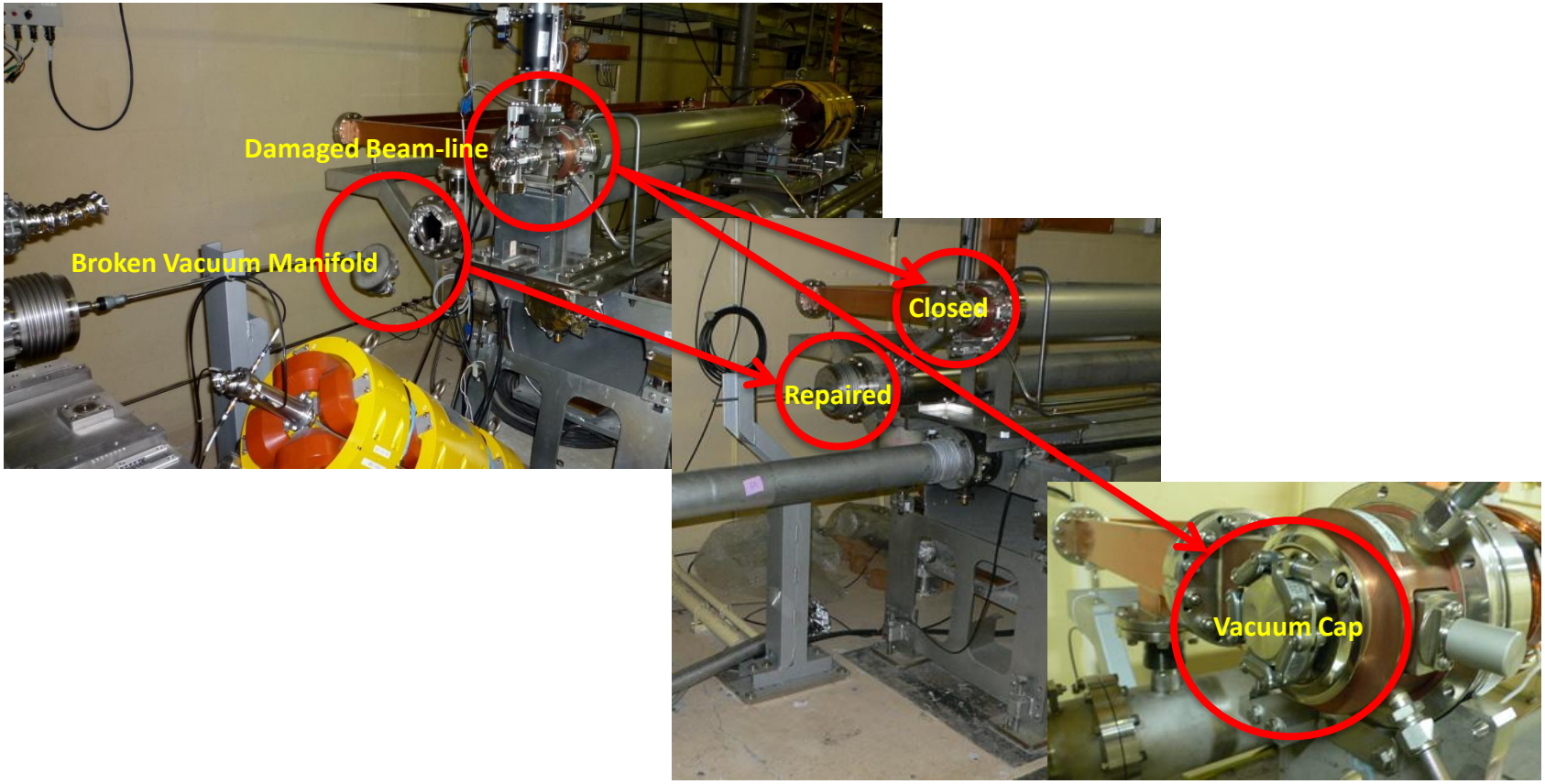
Status of Upstream (5/8 Linac Sectors)





- The upstream part of the linac had been separated by a concreat shield wall in 2009 to upgrade Linac while continuing beam injection for PF and PF-AR.

Accelerator Units

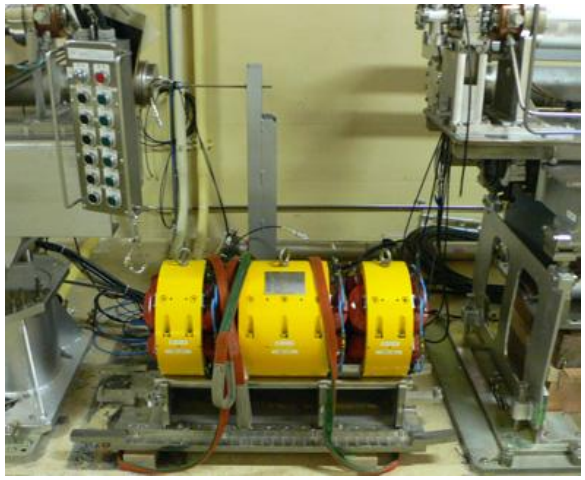


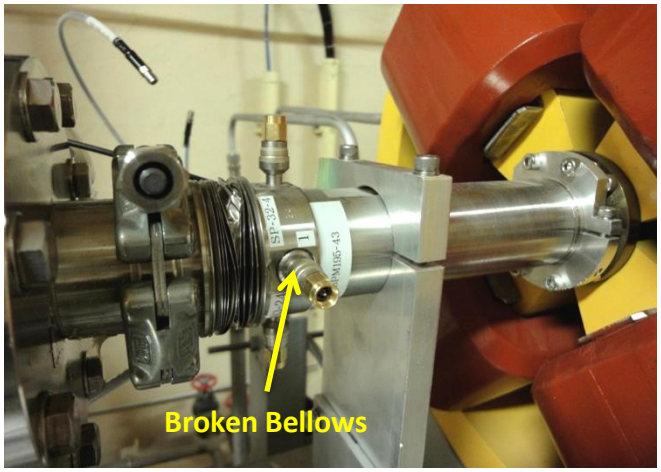
- Vacuum recovery of the upstream accelerator was initiated on June and completed by the end of October.
- However, the each accelerator units are isolated in vacuum; the beam-line components such as bpms are not yet installed.

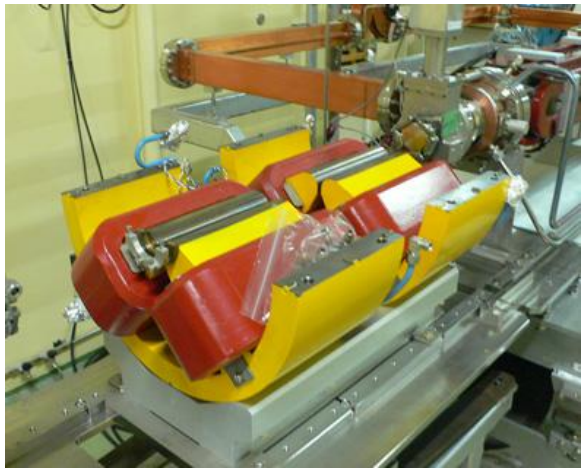
High-Power RF Tests

- **High-power RF test for the upstream accelerator units were done in November and December; and fortunately, no serious problems were not found!**

Beam-line Components

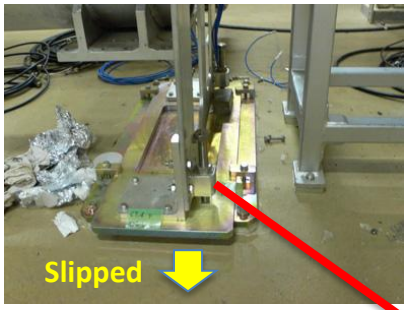


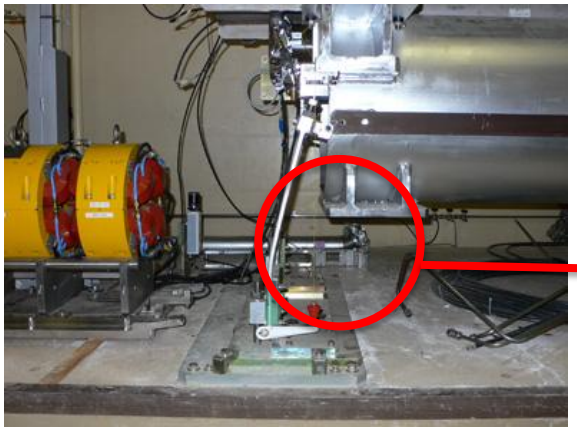


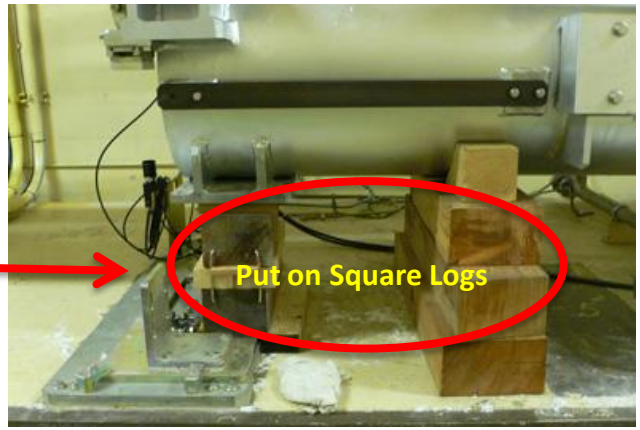


- **The magnet dropped was temporarily placed on the floor.**
- **The broken bpms were all removed and already repaired.**

Accelerator Girders







- The accelerator units were roughly corrected to their original positions.
- The broken girders were temporarily put on square logs.

Inflow Waters

- **Inflow water from the tunnel joints exceeded 50 t per day after the earthquake; however, by grouting materials into joints several times it has been reduced less than 2 t per day since autumn, 2011.**

Current status of Injector Group

- The earthquake caused heavy damage to Linac.
- But the earthquake gave us an energy to overcome the disaster and more.
- We also got some recovery budget as well as energy.
- The major goals and timeline to the SuperKEKB Injector Upgrade are not changed.
  - RF gun development (Mitsuhiro Yoshida) 21 Feb. 13:00 -
  - Positron source upgrade (Takuya Kamitani) 21 Feb. 13:40-

Thanks for Attention.