# Overview of Construction Status

Two topics are included in this talk:

- Recovery of KEKB rings from the earthquake
- Construction status

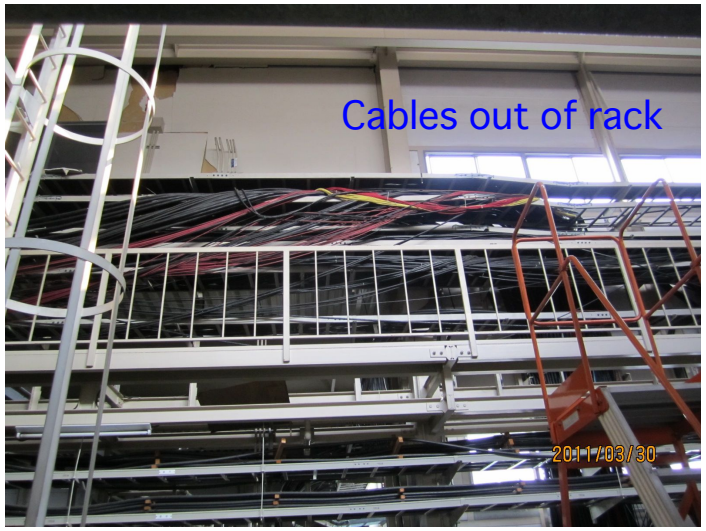
K. Akai (KEK)

Feb. 20, 2012

17th KEKB Accelerator Review Committee

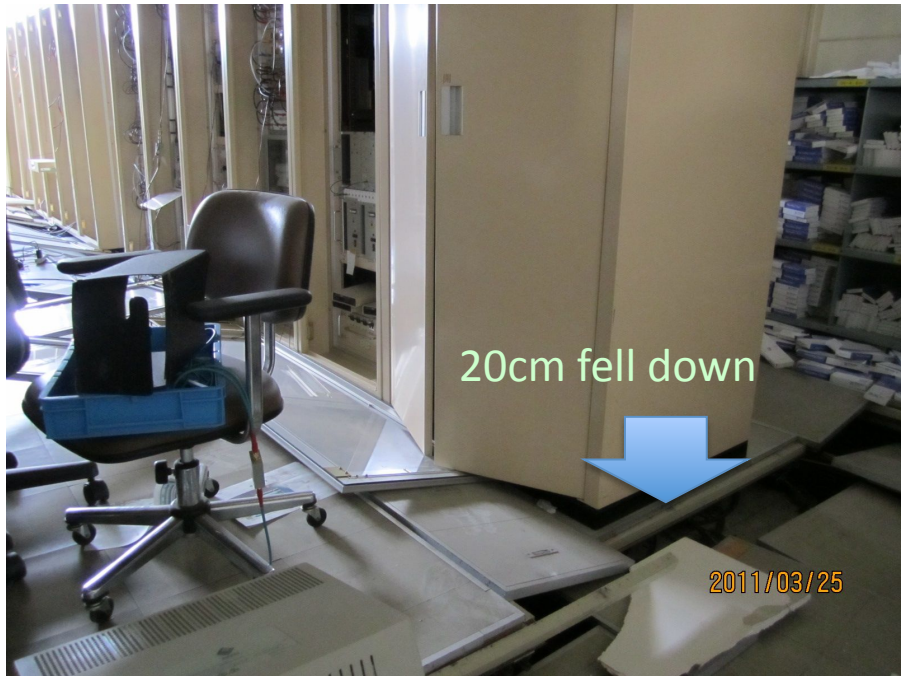
# Recovery of KEKB Rings from the Earthquake

# D5 power supply building


Panels and floor in the control room


# LLRF in D5

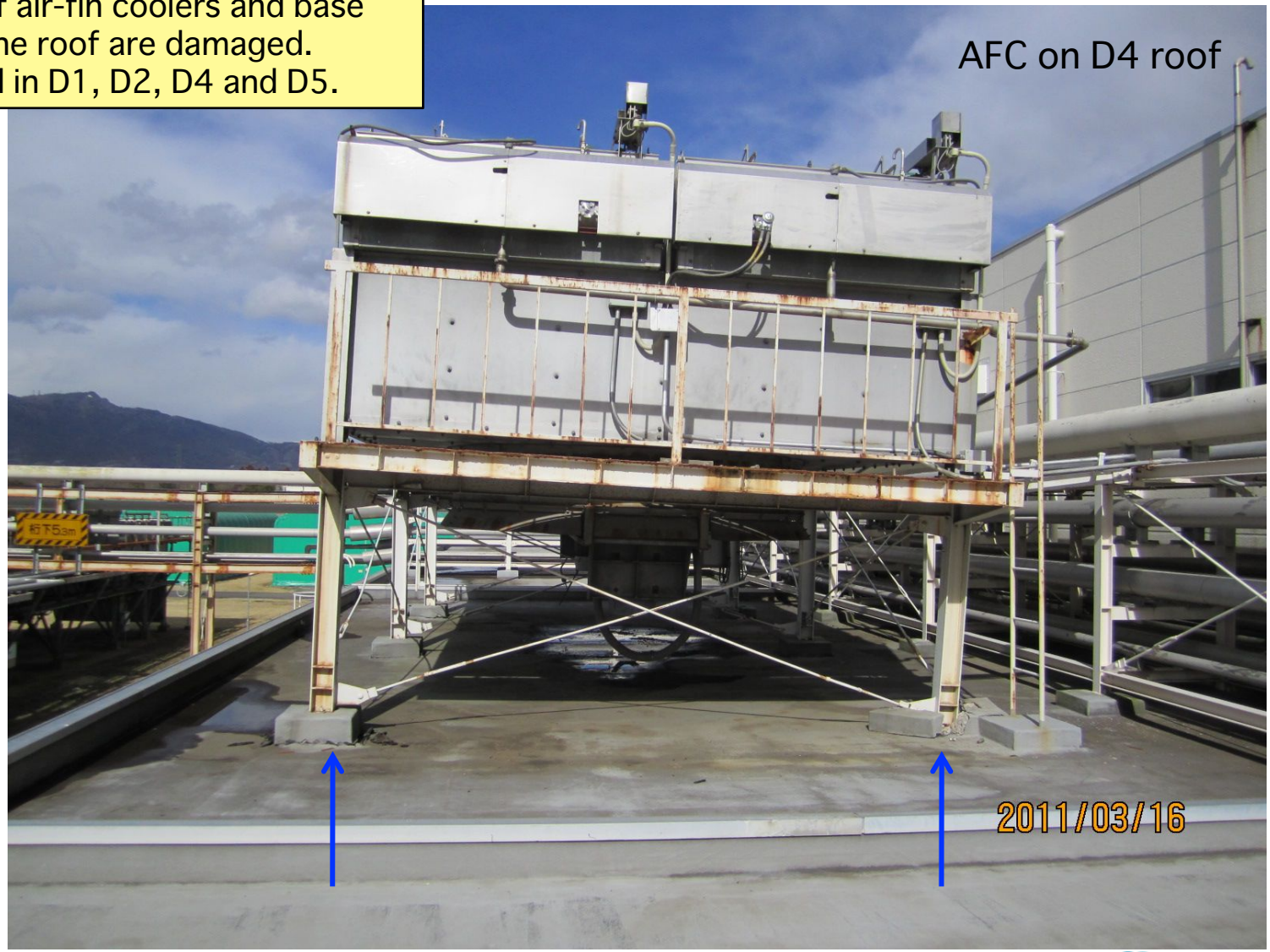



- More than 10 LLRF control racks for 2 RF stations fell down with floor by 20cm. Cables under the floor also damaged.
- Other 10 racks fell down by 1cm.

- More than 30 racks have been removed. Most of the cables, some of which are directly connected to tunnel, were also removed.
- Repair floors underway.
- New LLRF system to be installed.

# Air-fin cooler on the roof for klystrons

- Stands of air-fin coolers and base plates on the roof are damaged.
- Damaged in D1, D2, D4 and D5.



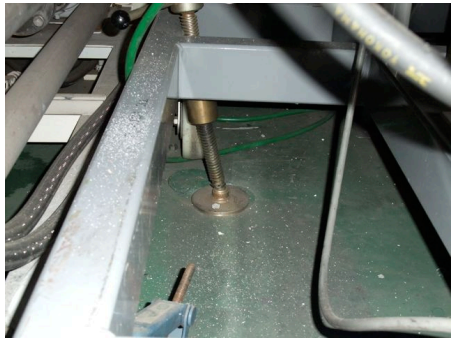
# Klystrons

- Stoppers of klystron sockets are damaged (half of all 35 klystrons).
- Klystron positions moved (almost all).

M. Yoshida

Stoppers damaged

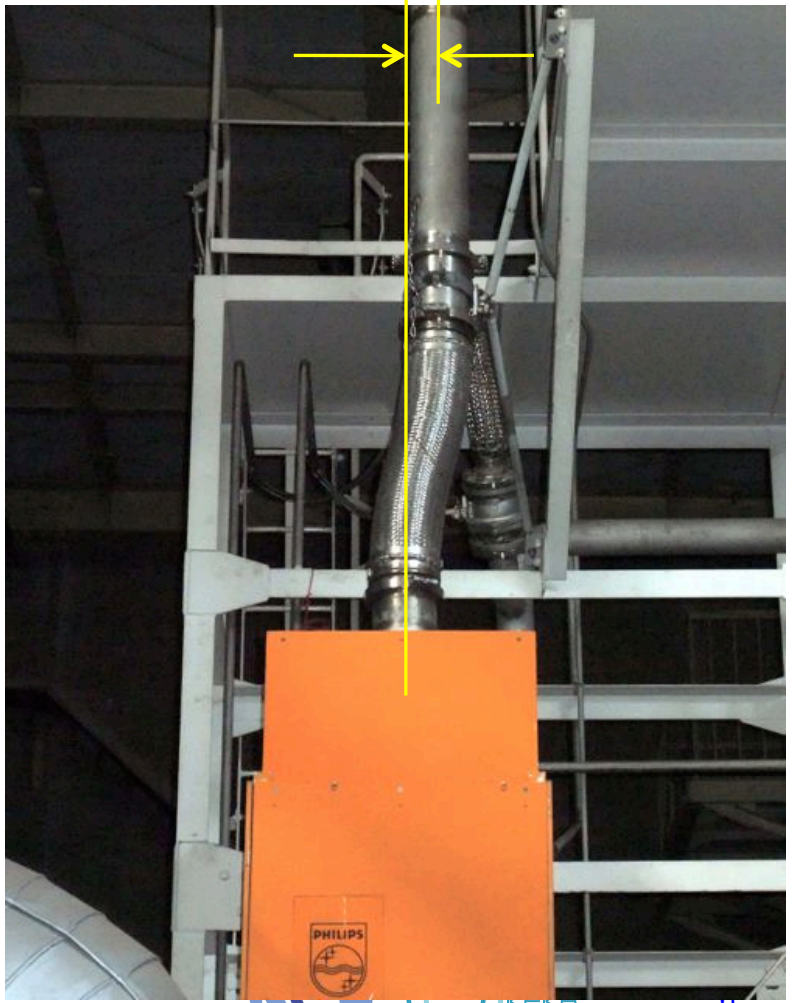
Stoppers deformed



Anchor bolts at cooling tower released

- Pumping system successfully restarted, and vacuum in klystrons was healthy.
- Stoppers are being reinforced.
- High power test to be conducted.

Position moved



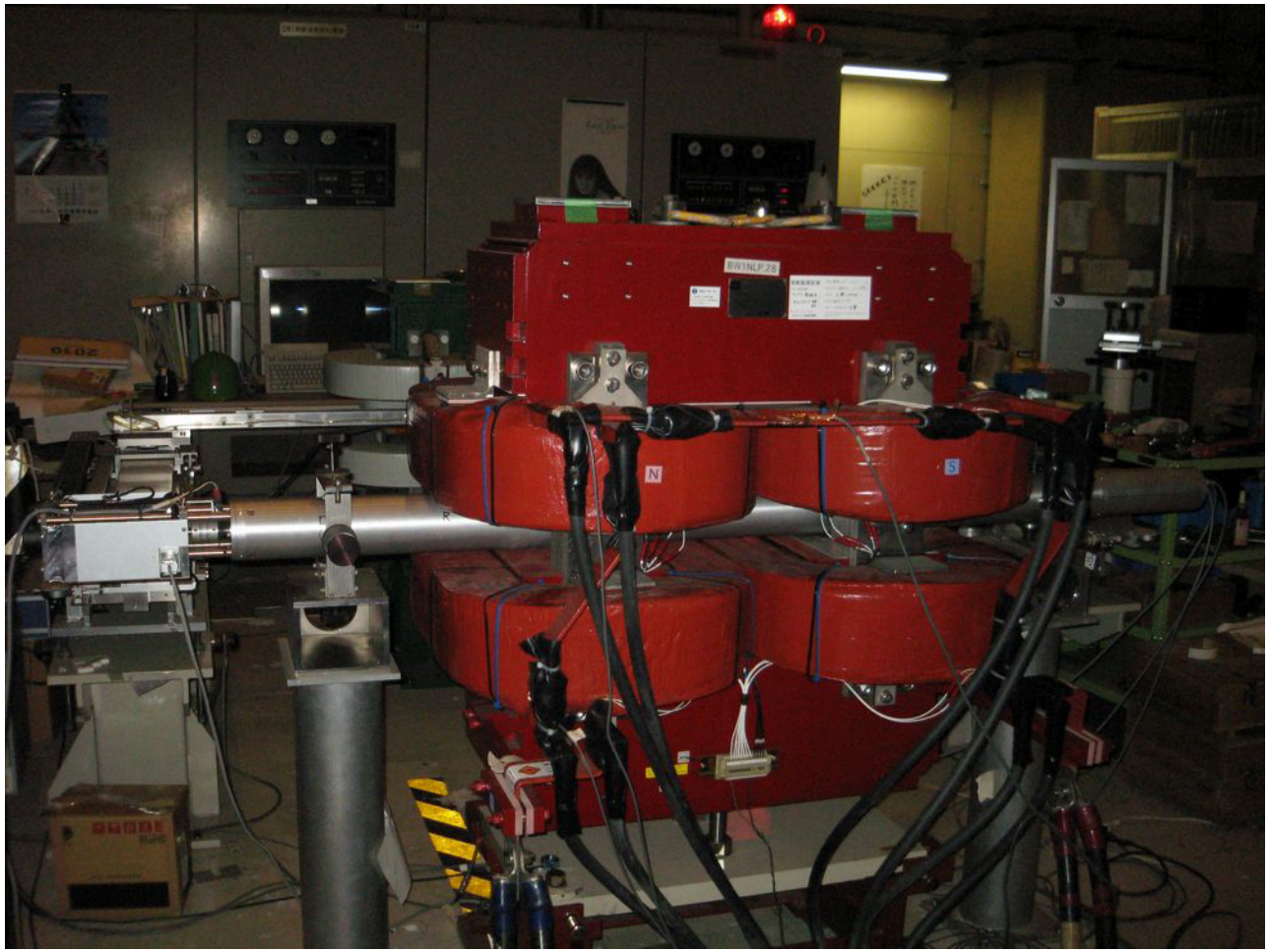
# Wiggler magnets in stock building

- Magnets that were stocked in a building moved and collided each other.
- Coils of some magnets seemed deformed.



# Wiggler magnets check after 3.11

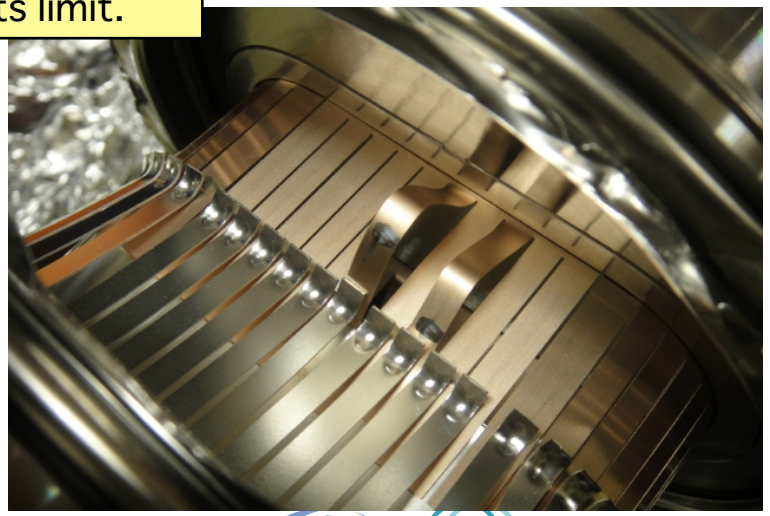
- Field measurement of all (~150) wiggler magnets was performed.
- Fortunately, all magnets are found healthy.



# Beam pipe bellows

- 21 bellows in D1 were opened, and checked inside.
- One of them had damage on three RF contact fingers.
- It is suspected that it shrank due to the earthquake.

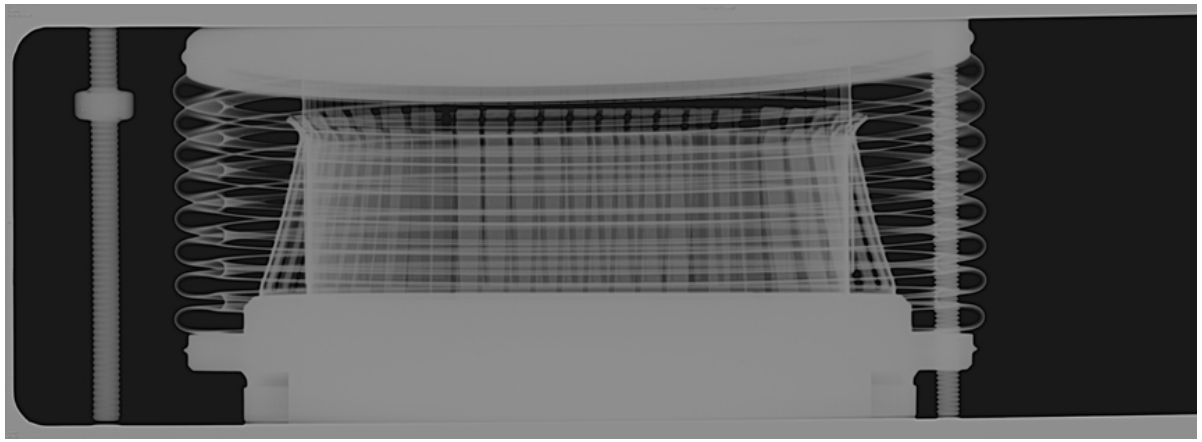
- 3 bellows in D11 were opened and checked inside.
- One of them had damage on three RF contact fingers.
- It is suspected that it shrank after expanded to almost its limit.



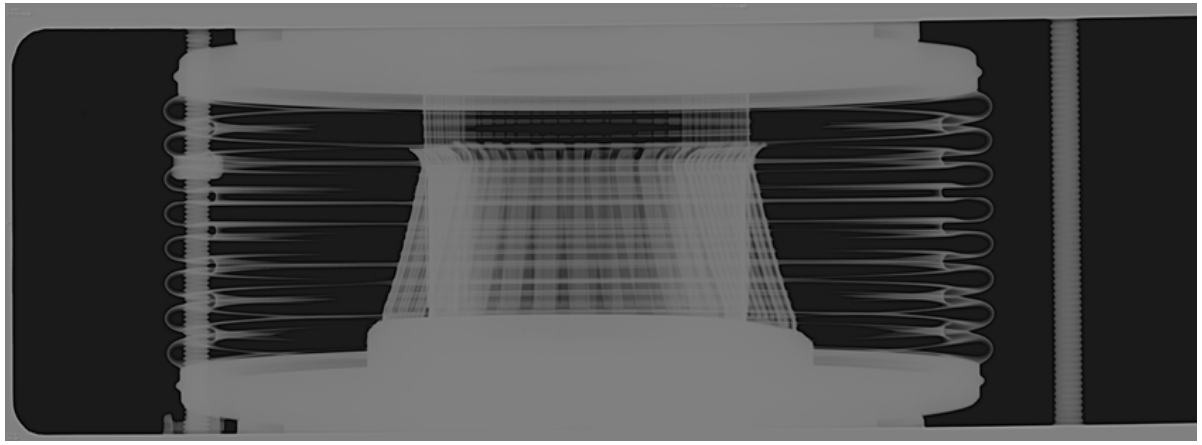
# X-ray check of all bellows planned

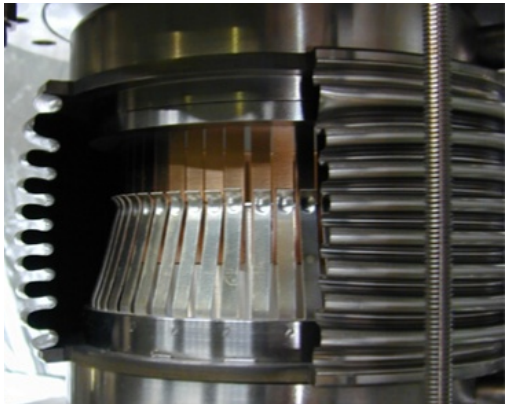
- Damage inside bellows can be checked using X-ray without opening to the air.
- All HER bellows will be checked this year.

Y. Suetsugu



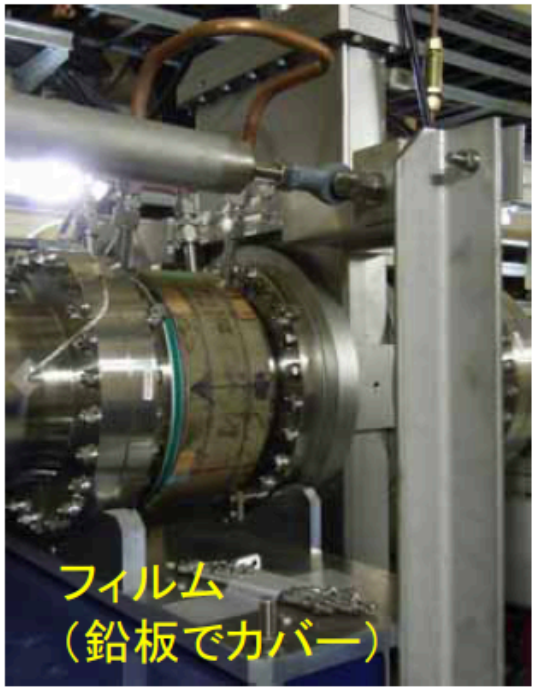
撮影条件
IPサイズ：3・1/3×12インチ
X線：110kV、5mA
距離：700mm
露出：5sec



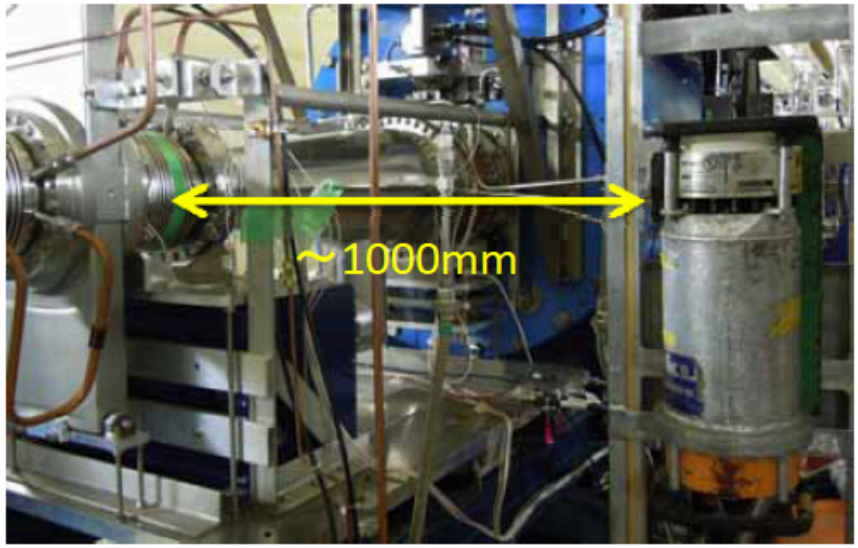


# 撮影の様子







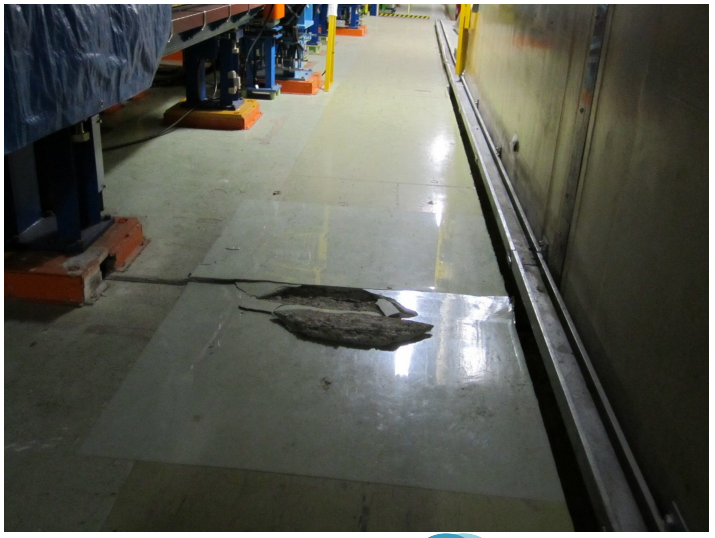


# Tunnel floor, wall, ceiling

Big gap (several mm) generated at expansion joints.
Alignment of magnets shifted accordingly.

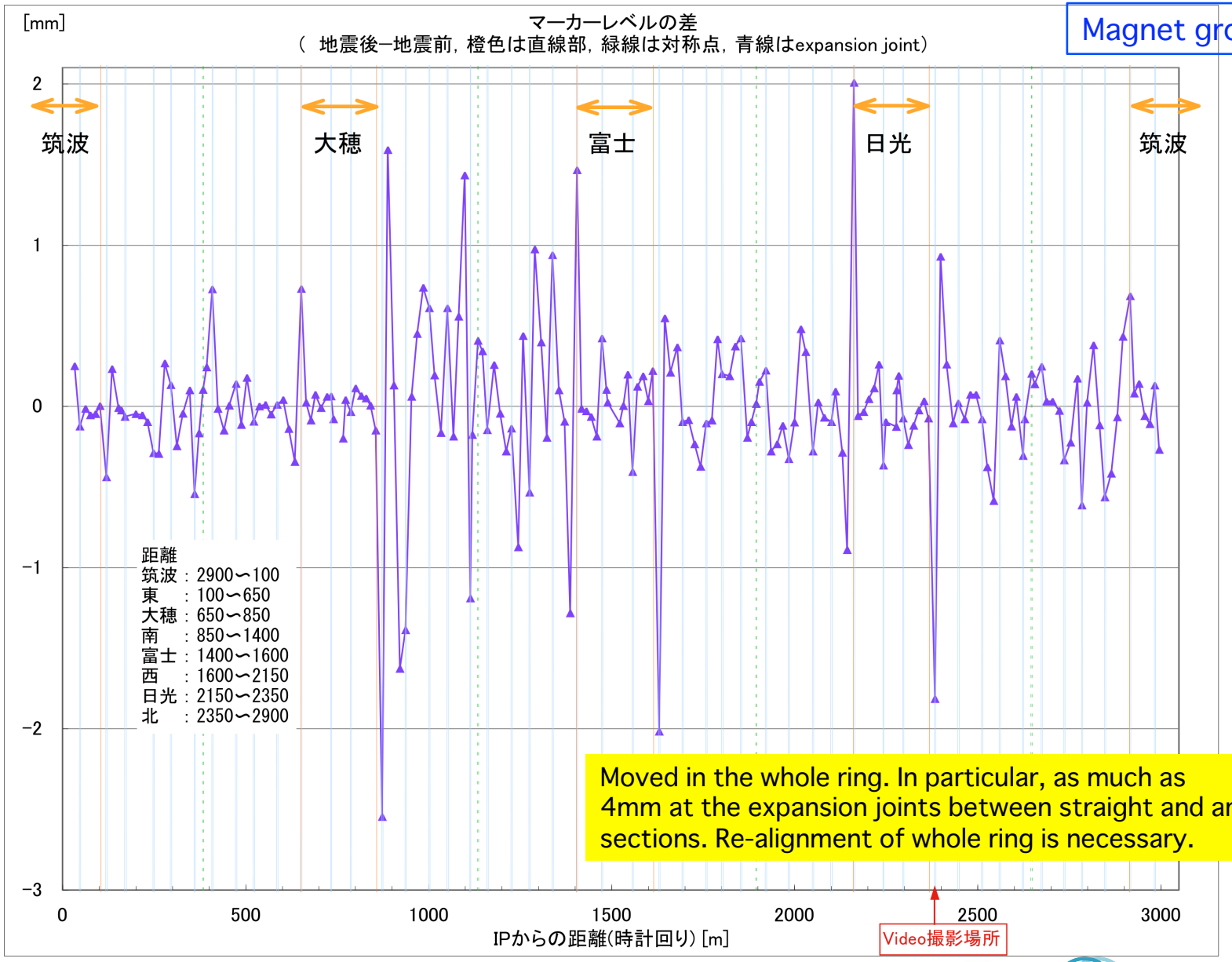
↑ Floor crack at D11 expansion joint
↓ Floor crack at Fuji expansion joint

↑ Water leak at D10 expansion joint ceiling
↓ Floor crack at the same expansion joint

# Difference between before and after the earthquake

Magnet group




Moved in the whole ring. In particular, as much as 4mm at the expansion joints between straight and arc sections. Re-alignment of whole ring is necessary.

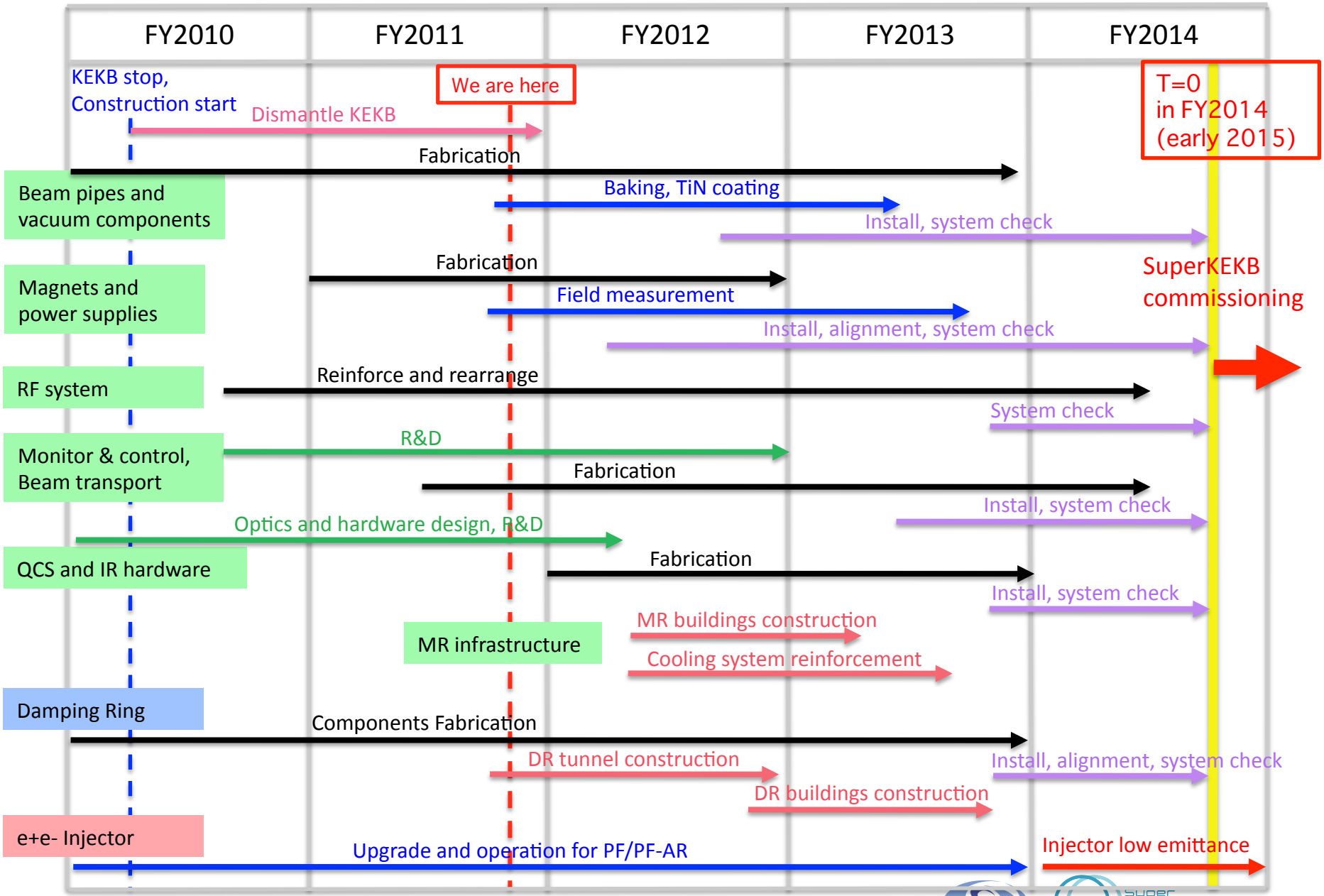
# Summary of the earthquake issues

- Damages
  - Serious damage on various components in power supply buildings, including klystron stands, air-fin cooling towers, LLRF, and monitor control system.
  - Damages on components in the tunnel seemed lighter than those in the buildings.
  - HER bellows had some troubles. Need investigation.
  - The expansion joints in the tunnel moved, and magnets alignment changed.
  - Other components such as radiation shields, cooling pipes, some magnets.
- Recovery
  - Urgent cures (vacuum leak check, field measurement, system check etc.) were done immediately.
  - Fortunately, all wiggler magnets in stock buildings found healthy, according to field measurement.
  - Large scale recovery work started after the supplementary budget for restoration and rehabilitation became available in January 2012.
  - Investigation of damages still continues, including X-ray survey of bellows, high-power test of klystrons, etc.

# Construction Status

# SuperKEKB construction schedule

Revised on Feb. 10, 2012



# Commissioning plan

- Phase 1: commissioning with Beast II
  - Start early 2015 in FY2014, and continues for about half an year.
  - Hardware and optics tuning, vacuum scrubbing, BG study, and collision tuning will be performed.
  - Target luminosity in this phase is $1 \times 10^{34}$ $cm^{-2}s^{-1}$.
  - Belle II solenoid is required to be implemented by then for the low beta beam tuning.
- Phase 2: commissioning with Belle II
  - Start at the end of 2015.
  - Machine tuning continues to increase luminosity with Belle II data taking.
- This plan is agreed between SuperKEKB accelerator and Belle II.

# Prioritizing for T=0

- Emittance
  - The design emittance is targeted from the beginning (T=0). Main Ring magnets, beam pipes, injection system, etc. should be completed by then. The Injector and DR should satisfy the low emittance at T=0.
- $\beta y^*$
  - Although we may start with detuned optics, $\beta y^*$ should be squeezed in the commissioning phase in about half year. Necessary hardware to achieve design $\beta y^*$ must be implemented by T=0.
- Beam current
  - Considering budget profile and schedule, about half the design beam current is targeted in the first commissioning phase.
  - Some components as well as infrastructure needed for the design beam current may be postponed after T=0. However, works that are difficult to do after the commissioning, such as rearrangement of cavities, reinforce cooling pipes in tunnel, will be completed by T=0.
- Bunch charge at Injector
  - Charge requirement for Linac and DR is set to match the beam current increase (roughly, 1 nC at T=0, 2 nC at +1year, 4nC at +2 years). This is to make a clear target for the RF e- gun and e+ source R&D and the Linac and DR construction schedule.

# Beam Energy

- Design
  - Original design maximum energy is 11.05GeV at $\Upsilon(6S)$.
- Recent request for higher energy
  - Requirement to investigate feasibility and issues for higher energy more than 11.5 GeV to around 12GeV was given by Belle II last autumn. The high energy running, if any, will be after several years running at $\Upsilon(4S) \sim \Upsilon(6S)$.
- Investigation
  - We investigated limitations from various components such as Linac, BT, QCS, Power supply for magnets, etc. Present attainable $E_{cm}$ is 11.24GeV, limited by e- Linac and e+ BT magnets.
  - In order to inject the electron beam to HER at the required energy for 12 GeV operation, there must be huge reinforcement of Linac (replacement of S-band with C-band, 7.571 -> 8.6 GeV; current estimation of cost is about 24 Oku-Yen).
  - From the viewpoint of the cost and labor, energy ramp-up of HER is supposed to be more realistic, so we will study its possibility.
  - Development of C-band units for Linac will also be promoted.

# Request from Belle II regarding high energy running of SuperKEKB

November 8, 2011

Dear Akai san, Enomoto san and Koiso san,
( cc to Oide san )

On behalf of the Belle II collaboration, we would like to ask you and the KEKB accelerator team to investigate the maximum possible obtainable center of mass energy of Super KEKB and the issues associated with achieving it.

A reason for this request is a recent discovery by Belle of the two charged bottomonium resonances in the Upsilon (5S) decays. This remarkable result likely means that we now enter a new era of heavy quarkonium physics for which Super KEKB can provide unique opportunities. In particular, based on Heavy Quark Effective Theory, we expect the existence of exotic bottomoinum states near and above the thresholds of B*B*bar, Upsilon (5S).

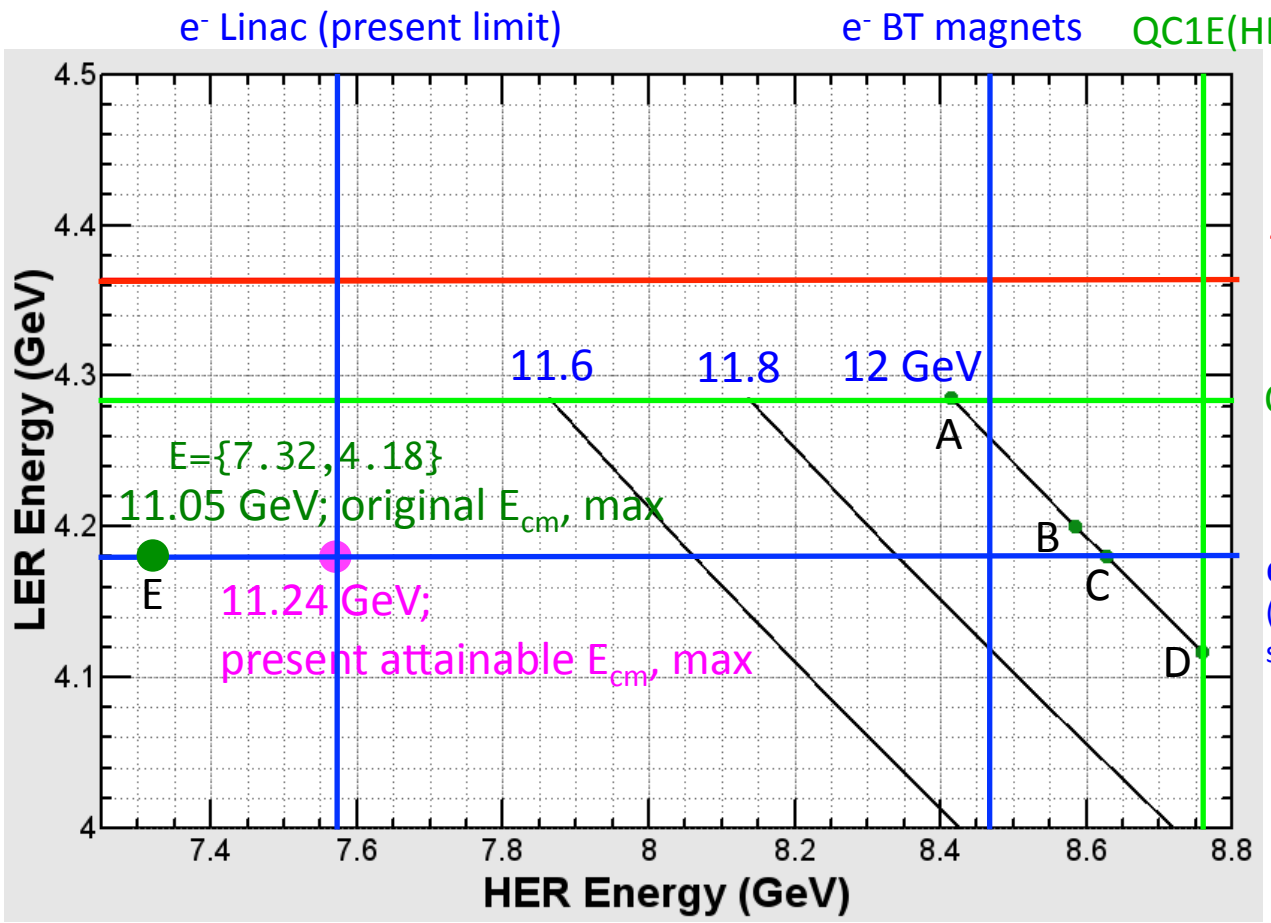
These states, however, cannot be produced in a single-pion transition from Upsilon (5S) due to G-parity conservation rule. The only possible way to produce them can be by the emission of a rho meson from highly excited Upsilon states, and therefore, the total CMS energy of about 12 GeV is necessary. We expect meaningful physics results with running at this high energy even in case of significant luminosity degradation.

Hence, we request Super KEKB group kindly provide us with the information regarding its feasibility and the issues associated with high energy running. It is our strong wish to understand the limiting factors of high energy running and to work with you to solve the potential problems if possible.

We thank you very much in advance and look forward to hearing from you.

Peter Krizan
Spokesperson, the Belle II collaboration
Hiroaki Aihara
Chair of the Executive Board, the Belle II collaboration

# Limitations for Higher $E_{cm}$

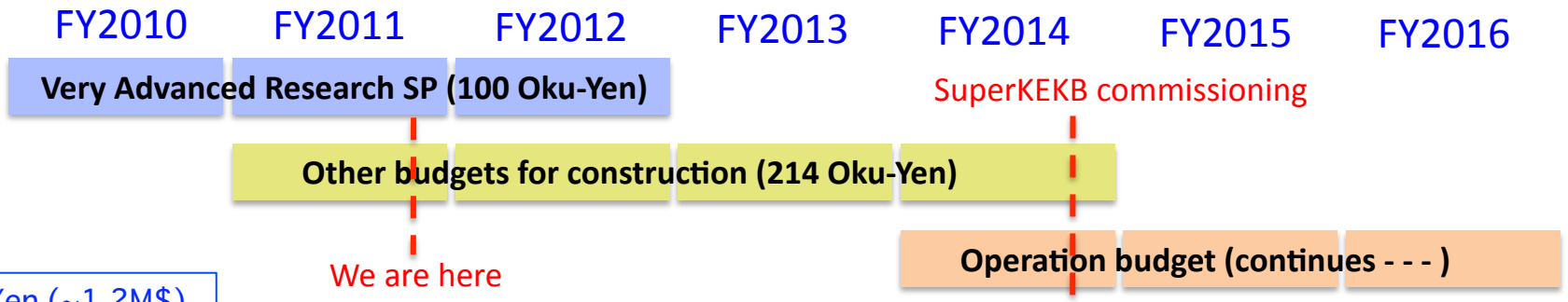


# Design Issues to be fixed

- Optics and IR design
  - Both sides of IR (300m Tsukuba) vacuum components and magnets production scheduled in FY2012.
  - QCS fabrication should start in FY2012.
- Sextupole scheme
  - Rotation sextupole magnets are required in LER.
  - In HER, normal sextupole and independent skew-sextupole may be OK at T=0.
- BG, Collimation system, radiation shield
  - BG estimation, movable masks R&D, investigating radiation going on.
- Requirement for BPM detectors
  - Specification and how many at T=0?
- Injection scheme
  - Synchrotron injection in HER?
- Abort system
  - Possible scheme to abort nano beam.

# Budget

- Budget
  - Total construction budget is 314 Oku-Yen for Rings, Injector, and Belle-II.
  - Most of the budget comes year-by-year based.
  - Operation budget is expected in FY2014 and later.




Unit: Oku-Yen (~1.2M$)

| | FY2010 | FY2011 | FY2012 | FY2013 | FY2014 | Total |
|---|---|---|---|---|---|---|
| VARSP | 75.0 | 10.5 | 14.5 | 0 | 0 | 100.0 |
| Others | 0 | 41.6 | 40.2 | 61.6 | 46.7 | 190.0 |
| Facility | 0 | 4.5 | 12.4 | 7.2 | 0 | 24.1 |
| Total | 75.0 | 56.6 | 67.1 | 68.8 | 46.7 | 314.1 |
| Status | Supplied | Supplied | Submitted to the Diet | To be submitted to the Diet | To be submitted to the Diet | |

# Human Resources

- HR of KEK staff
  - Change of permanent staff members from the last MAC
    - Apr. 2011: One retired. Three newly hired. Two joined from other groups.
    - July 2011: One joined from other group.
    - Apr. 2012: Two will retire. Three expected to be newly hired. Some join?
  - Senior staffs after retirement
  - Young members at term positions
- Other helps
  - Collaborations going on
  - KEKB operation crew (company persons) to help construction work
- Situation of short HR seems getting better

| Date | Status | Needed FTE | Available FTE of permanent staffs | Non-permanent staffs added |
|---|---|---|---|---|
| Dec. 2010 | under construction | 77 | 56 | 61 |
| Apr. 2011 | under construction | 77 | 60 | 66 |
| Apr. 2012 | under construction | 77 | 62 +some? | 67 + some? |

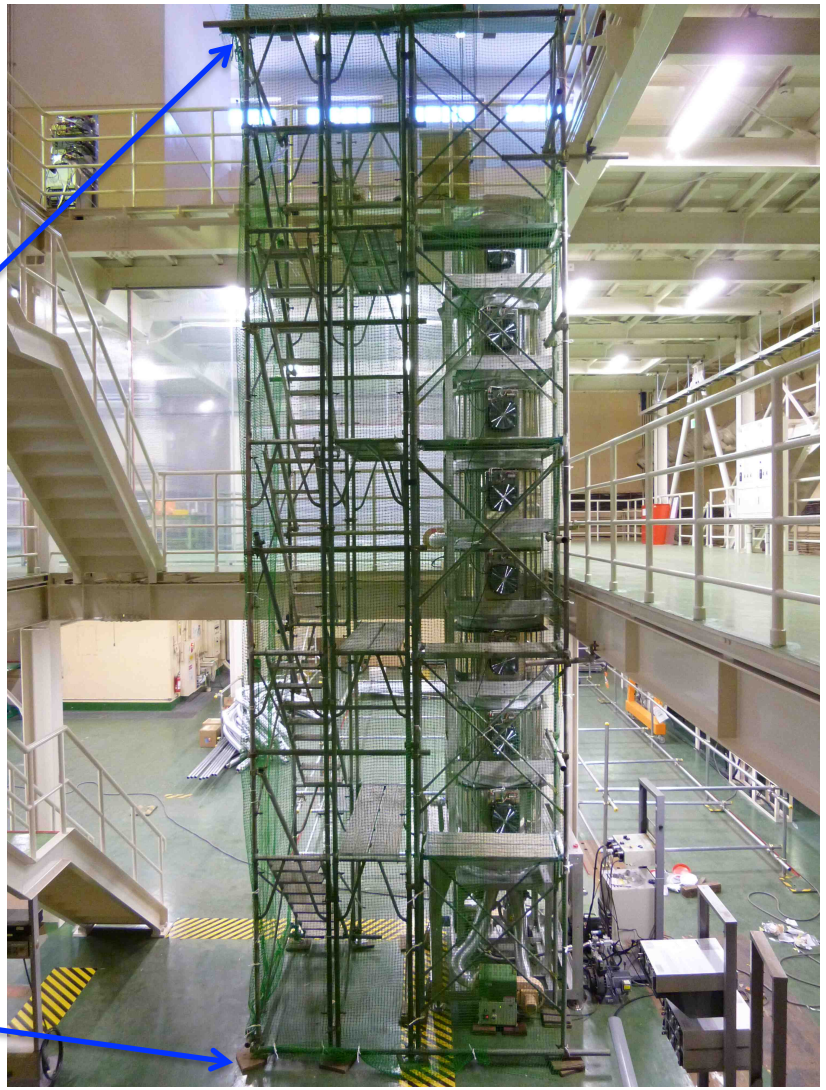
# Vacuum system

- Fabrication of vacuum components -> Talk by Y. Suetsugu
  - Aluminum ante-chamber beam pipes for LER arc sections (700 pieces, 2km length) on going in FY2011.
  - Bellows and gate-valves for arc and wiggler sections to be completed soon.
  - Copper beam pipes for wiggler sections in LER and HER to be completed soon.
  - Beam pipes, bellows and gate-valves in Tsukuba straight section for both rings to be ordered in FY2012 and 2013.
  - Movable masks, SR and X-ray monitor chambers will be made in FY2013 and 2014. Currently, R&D is going on.
  - Replacement of some HER components for higher beam current before or after T=0 depends on budget.
- Baking and TiN coating system -> Talk by K. Shibata
  - Deck for vacuum work in Oho has been rebuilt after old AMY detector of TRISTAN was removed.
  - The first baking system and the first TiN coating station has been built in the vacuum deck.
  - More sets of baking and coating stations will be built soon.

# LER beam pipe fabrication @BINP

# TiN coating machine

TiN coating machine (1st vertical type) in Oho experimental hall



# Magnet system

-> Talk by H. Iinuma

- Fabrication of magnets
  - Fabrication and field measurement of LER 4m dipole magnets is going on. They will be installed in tunnel in the first half of FY2012.
  - Half-pole and single-pole wiggler magnets, LER V-steering magnets, some of Q magnets on going in FY2011.
- Fabrication of power supplies for magnets
  - Power supplies for main dipole magnets and wiggler magnets are going on in FY2011.
  - Power supplies of medium and small power will be ordered in FY2012 or later.
  - Power supplies for DR: some are ongoing, others will be in FY2012.
- Alignment and tunnel measurement
  - Measurement after the earthquake showed significant movement of tunnel.
  - Introducing GPS system and investigating the ground (boring, etc.) going on.

# Dismantle Tsukuba straight section

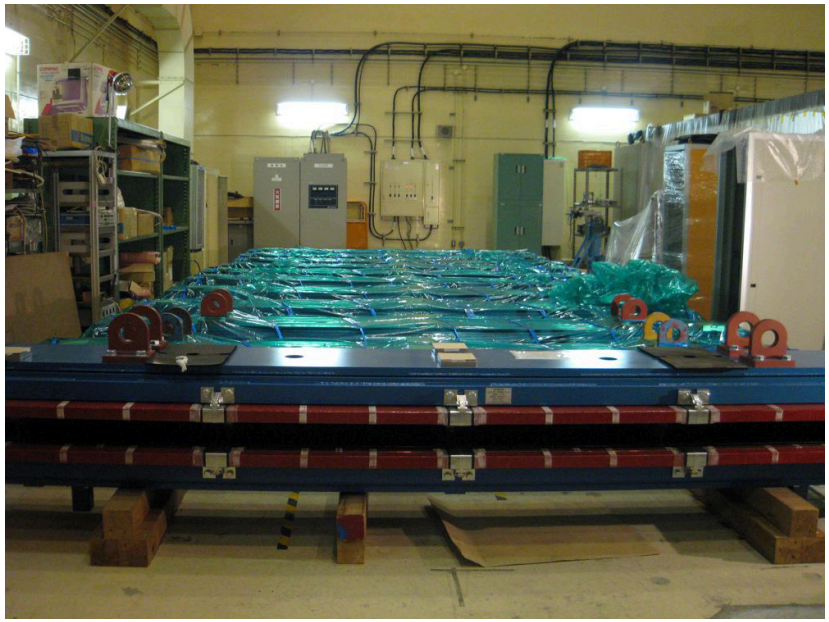

Dismantle both sides of IR (D1 and D2) done.

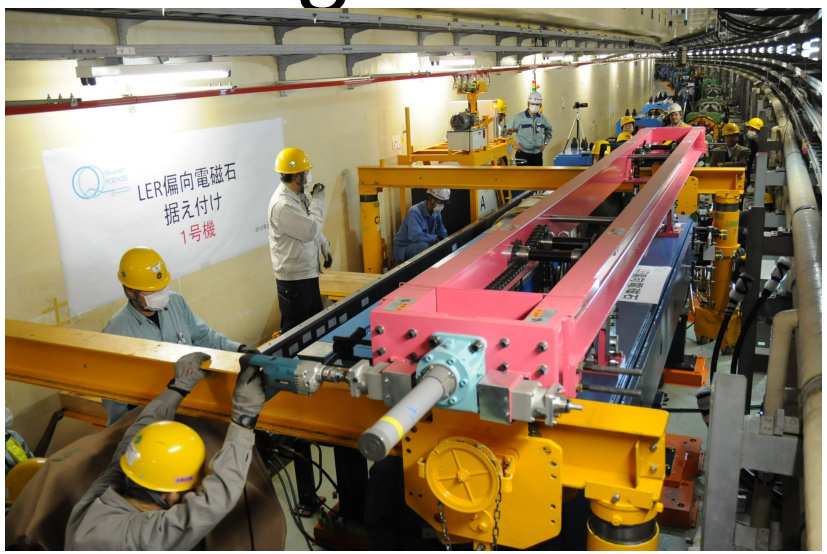
Magnets and cables have been removed. Old base plates were removed, and the floor has been cleared up.

# LER new 4m dipole magnets

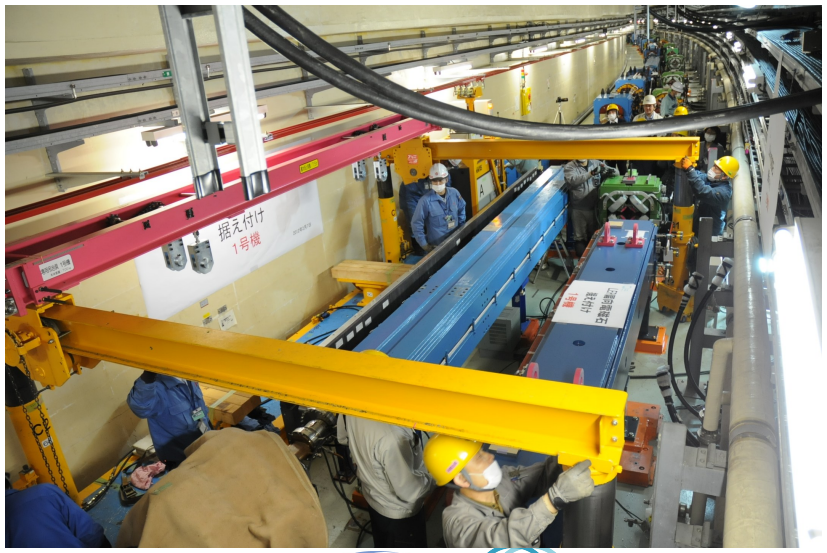
Field measurement set up

The first goods delivered to KEK.






Install test in the outer LER over existing magnets in the inner HER.

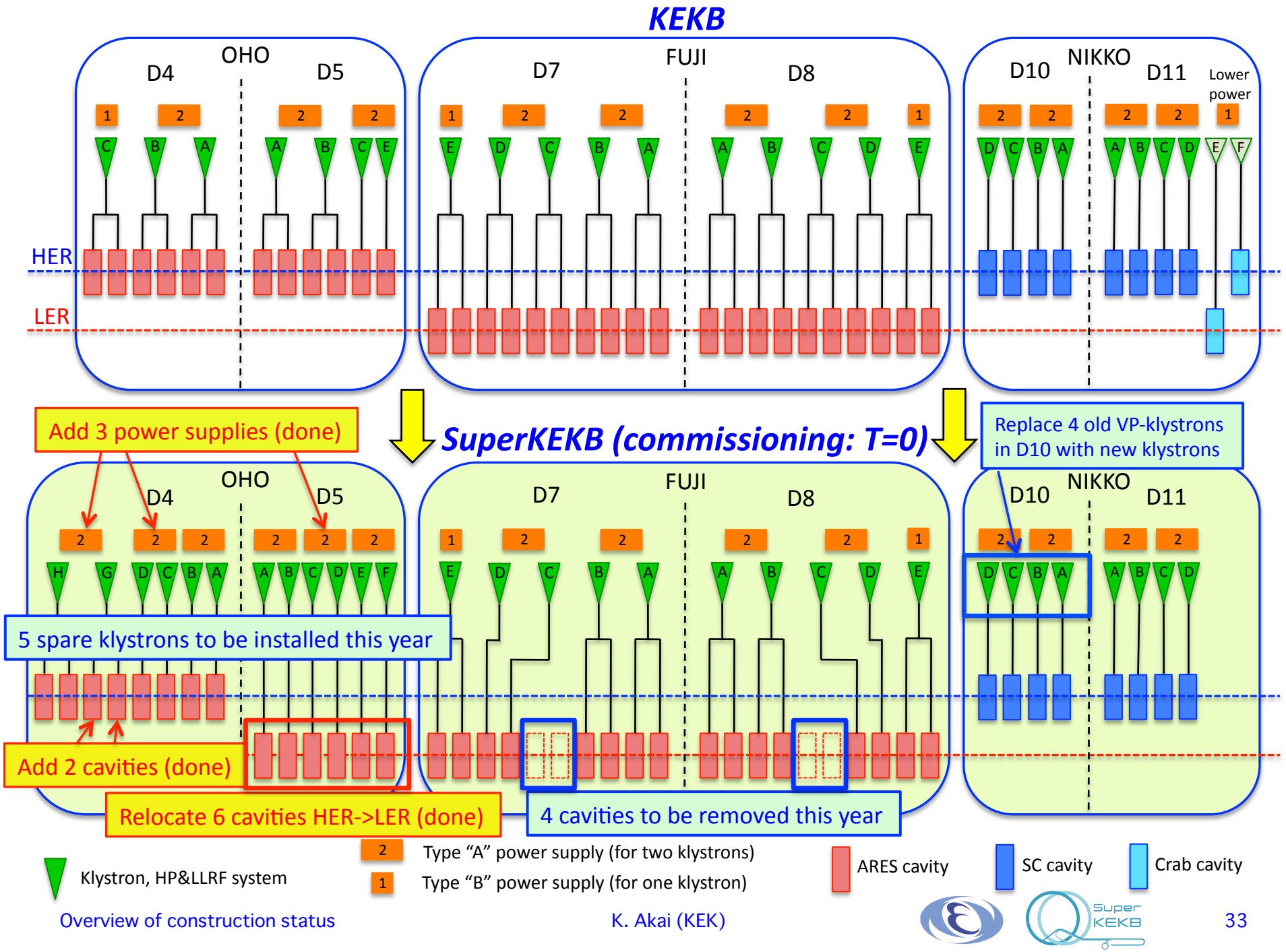


# Interaction Region

- A lot of critical issues
  - Optics design
  - QCS design and fabrication
  - IR hardware design and assembly
  - Background
    - Storage beam
    - Injection transient, blow-up, mask, IR aperture
    - Vacuum pressure at large beta (beam-gas)
  - Error tolerance at local chromaticity correction and correction method
  - Ripple of power supply
  - Collision feedback
- Will be presented in the following talks today:
  - Dynamic aperture and IR modeling (A. Morita)
  - Error Tolerance and Optics Correction (H. Sugimoto)
  - IR Magnets (N. Ohuchi)
  - Beam Background (H. Nakayama)
  - IR Vacuum Chamber and Assembly (K. Kanazawa)
  - Collision Feedback (Y. Funakoshi)

# RF system

- Upgrade items
  - Change to 1 klystron to 1 ARES cavity scheme to increase beam power
    - Rearrange ARES cavities
    - Change input coupler of the ARES to increase coupling $\beta$ from 3 to 6
    - Add klystrons, power supplies, HPRF and LLRF
  - Cure for increasing HOM power -> Talk by Y. Morita
  - Develop new LLRF -> Talk by T. Kobayashi
    - Damaged LLRF in D5 by the earthquake will be replaced with new ones.
  - Develop Damping Ring Cavity -> Talk by T. Abe
  - Replace old components with new ones (klystrons, power supplies, etc.)

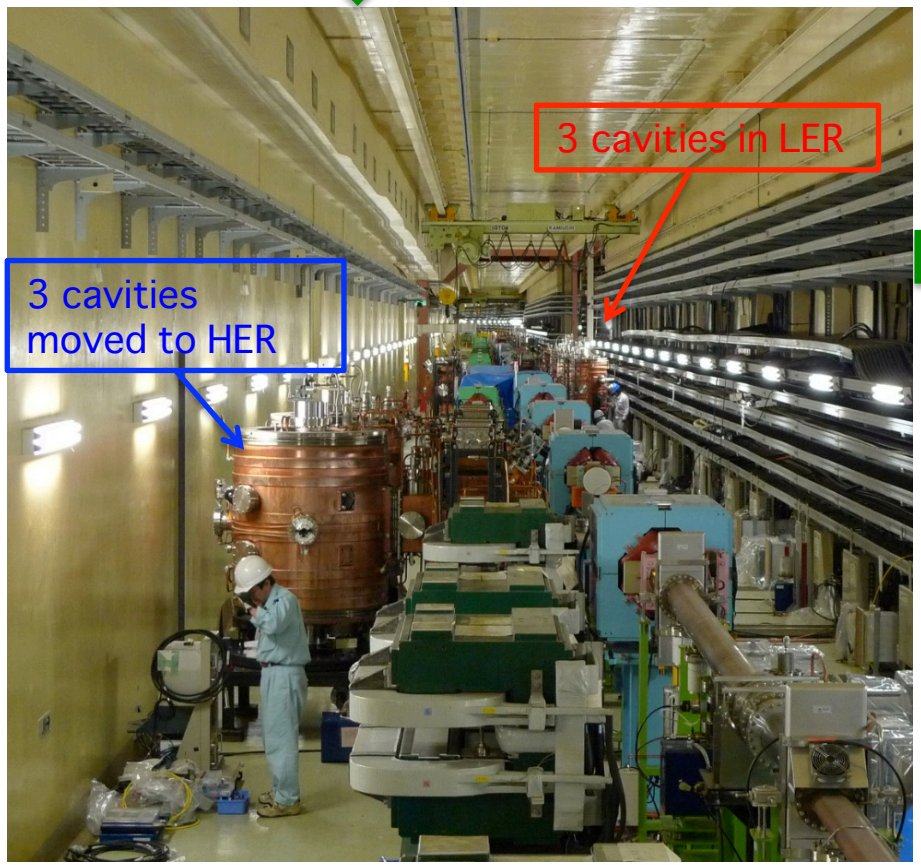

KEKB
OHO
D4
D5
FUJI
D7
D8
NIKKO
D10
D11
Lower power
HER
LER
Add 3 power supplies (done)
SuperKEKB (commissioning: T=0)
Replace 4 old VP-klystrons in D10 with new klystrons
5 spare klystrons to be installed this year
Add 2 cavities (done)
Relocate 6 cavities HER->LER (done)
4 cavities to be removed this year
Klystron, HP&LLRF system
Type "A" power supply (for two klystrons)
Type "B" power supply (for one klystron)
ARES cavity
SC cavity
Crab cavity

# Relocate ARES cavities in D5

To convert 6 ARES cavities from LER to HER.

(KEKB-D5): 6 cavities in LER

On the way

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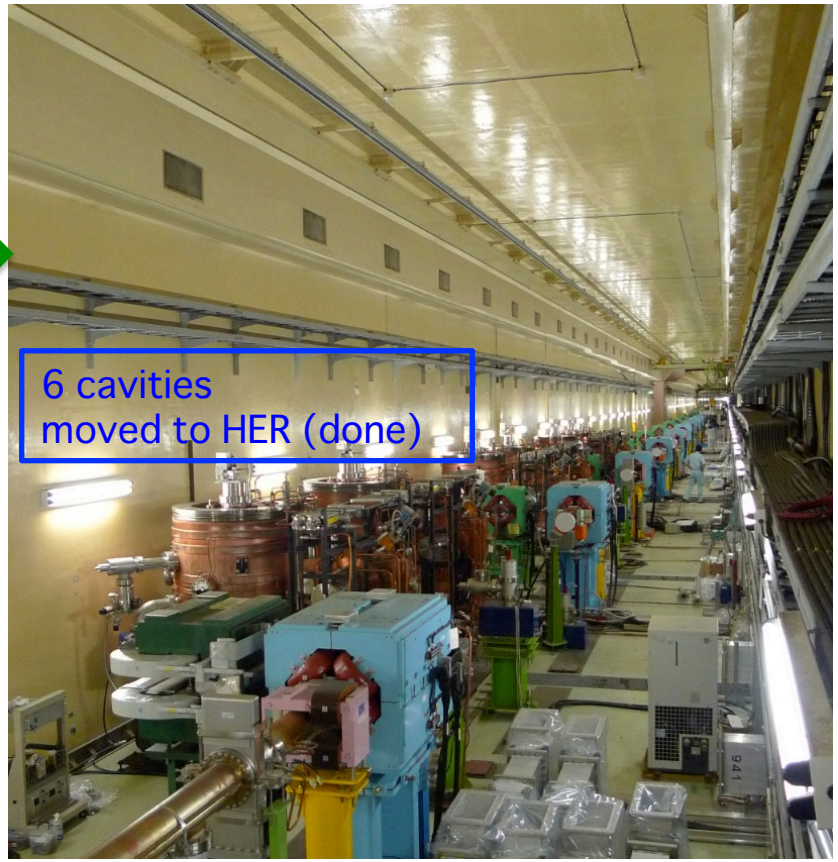
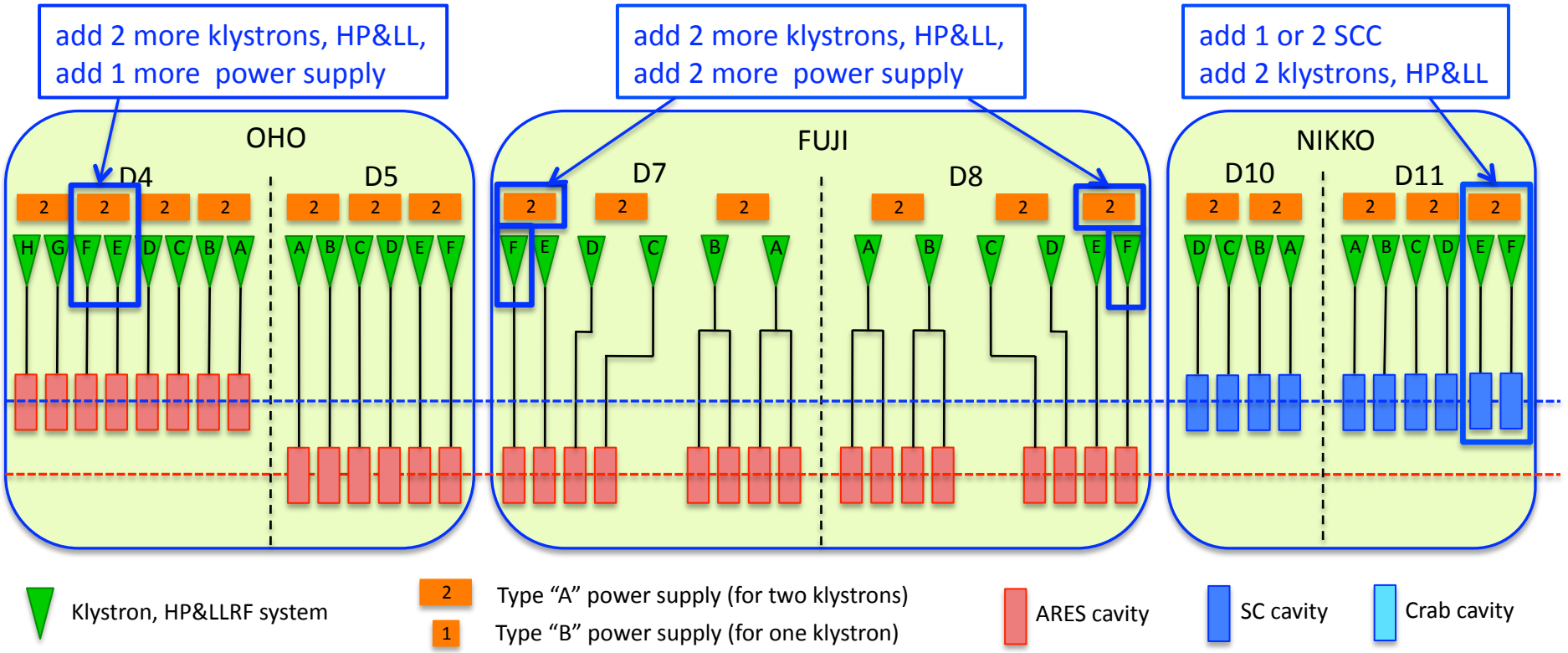


# *More reinforcement of RF for design beam current (after T=0)*



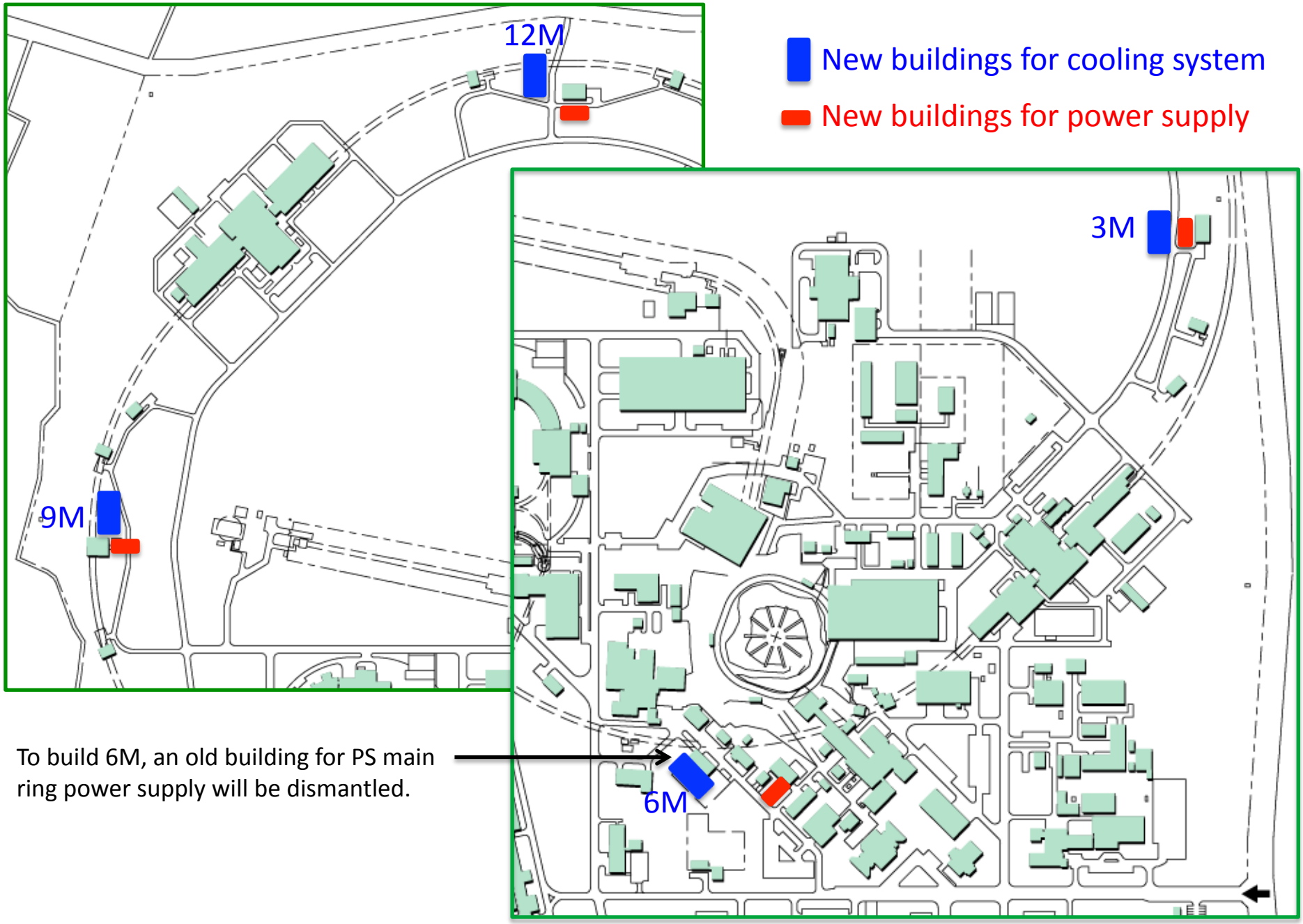

The reinforcement after T=0 depends on requirement, machine performance and budget.

# Monitors, Control, Beam Transport

- Present status
  - R&D on various monitor components including BPM detectors, bunch-by-bunch feedback system, X-ray monitors is going on.
  - Fabrication of BPM electrodes, amplifiers for FB, etc. is going on.
  - Design of beam abort system in progress.
- Will be presented in the following talks:
  - Beam diagnostics, Feedback systems (M. Tobiyama)
  - Photon Monitors (J. Flanagan)
  - Synchrotron Injection (T. Mori)
  - Beam Abort System (T. Mimashi)
  - Control and Timing System (K. Furukawa)

# Reinforce Cooling system

- Need for increasing cooling power
  - Three times for vacuum system (5MW→16MW).
  - 1.5 times for magnet system (10MW→16MW).
- How to do this
  - Four new buildings for cooling system will be built in FY2012～2013.
  - Cooling tower of existing system will be reinforced for higher current.
  - Replace existing cooling pipes in tunnel with larger aperture ones to increase water flow.
- Issue
  - Replacing cooling pipes is necessary almost all around the ring. This may interfere various works in the tunnel such as installing magnets and beam pipes. Furthermore, some of the existing or newly installed magnets may need to be temporarily moved. This may cause schedule delay.
- Measure
  - Possible ways of doing this work with minimum interference are now being studied by various contractors. Design of cooling system and piping is also ongoing. They will give reports by the end of this March to help us decide the way and schedule of tunnel work.



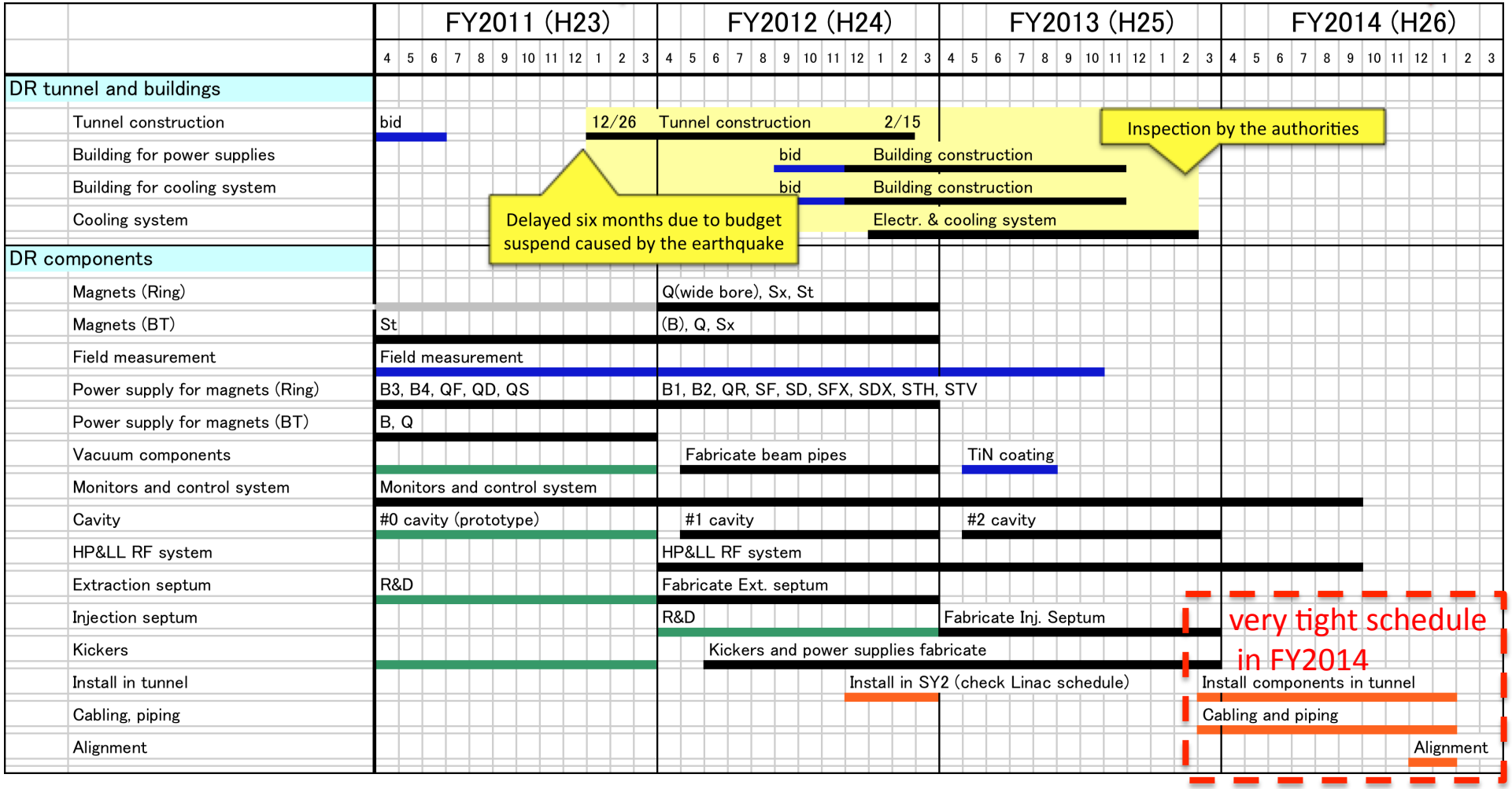

To build 6M, an old building for PS main ring power supply will be dismantled.

# Damping Ring

- Design
  - Optics design is almost fixed.
  - Remaining issue is to determine beam pipe cross section size from the view point of CSR and acceptance. -> Talk by H. Ikeda
- Components
  - Fabricating magnets and power supplies are ongoing as scheduled.
  - Test beam pipes (aluminum, ante-chamber) is being made. Mass production will be planned in FY2012.
  - R&D of DR cavity is going on. A prototype cavity will be completed in FY2011, and will be high-power tested soon.
- Tunnel and buildings
  - See, next slide.
- Issue
  - Since tunnel construction delayed for six months due to the earthquake, installation of components will start only one year before T=0. Schedule in FY2014 will be very tight with installation, cabling and piping, system check, etc.

# Damping Ring

DR tunnel construction delayed for six months due to the earthquake.
Installation can start after the inspection of buildings, only one year before T=0.



# Summary

- The earthquake caused some delay and additional works for SuperKEKB construction, but we manage to recover to be in time for T=0.
- Design work and construction work are going on at the same time in consistent ways. But time limit for some critical designs will come soon.
- So far, budget is supplied as planned, except for the delay due to the earthquake.
- Shortage of human resources is getting better.
- Construction is well ongoing, prioritizing for T=0.