HLS/WPS used at KEK

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Takatoshi Morishita (JAEA)

1. R&D activities
2. HLS/WPS commissioning at J-PARC LINAC
3. WPS at STF
4. HLS/WPS for ATF2, SuperKEKB?

HLS/WPS at KEK

1. R&D activities (in the past…)

HLS by S. Takeda et al.
IWAA2004, EPAC2004

1) Lowest cost for production
2) Best signal quality being free from environmental EM noise
3) Decreasing the temperature influence
4) Digital signal transmission system for long distance.

WPS by R.Sugahara et al.
IWAA2003

1)Low cost
2)Metallic wire (thin brass wire) with AC current
3)Noise?

Fig. 2 shows a schematic description of the present new HLS. The surface of the capacitive sensor is protected by anti-vapour absorbing material and the top surface attached by a heating circuit. In order to avoid the change of sensor position by environmental temperature, an invar rod supports the sensor plate.

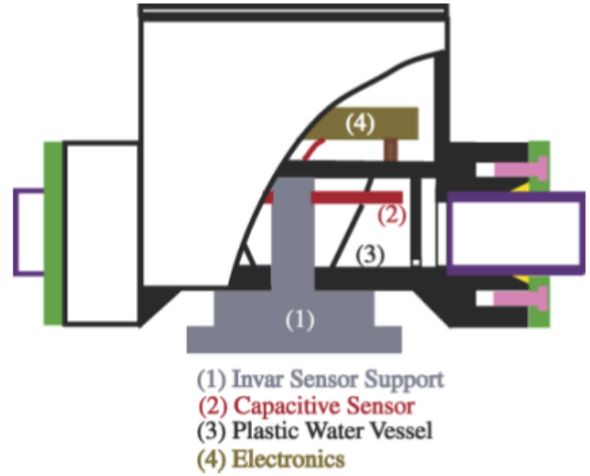
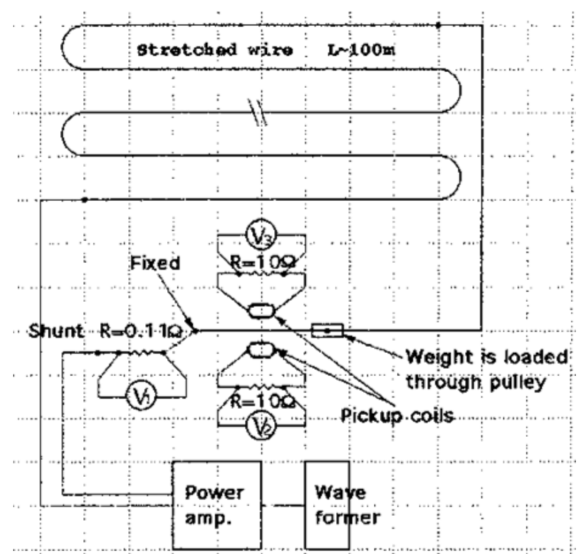
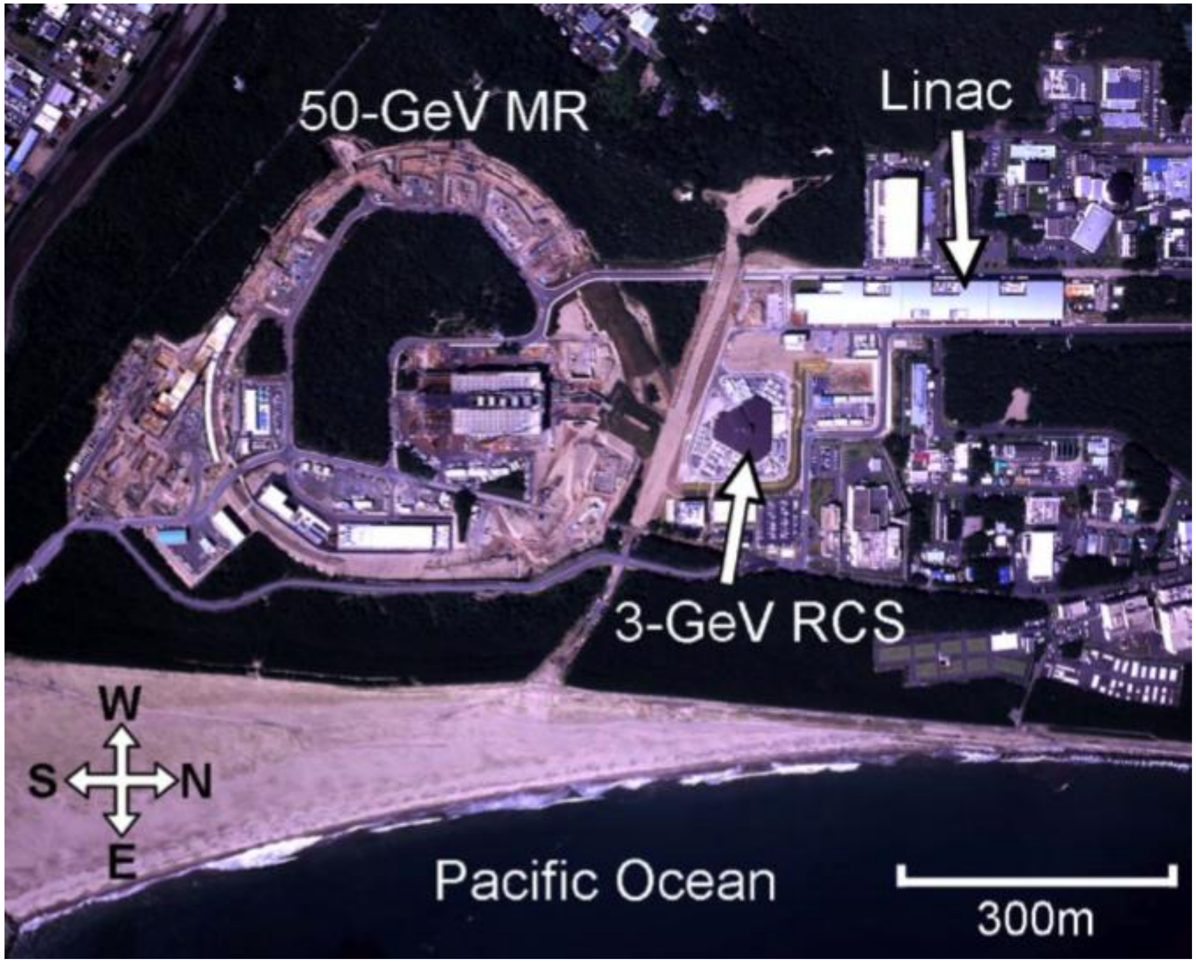


Figure 2: Schematic description of the new HLS.



2. HLS/WPS at J-PARC LINAC

T. Morishita, M. Ikegami, Nucl. Instr. and Meth. A (2009)



Motivation for a slow-ground-motion monitoring system
to improve operational stability under peculiar geographical and geological circumstances.
J-PARC accelerator is built on sandy soil with abundant groundwater.

J-PARC site & Requirements

J-PARC site

•The bedrock (mudstone) is covered with thick sandy soil.

  •~ 15 m deep on the upstream side of the linac tunnel.

  •Becomes deeper (up to 45 m) on the downstream side.

  → Might have different responses to a geographical perturbation, resulting in a local deformation of the accelerator tunnel.

•Effects of underground water as the linac tunnel is blocking one of the water veins.

Requirements for the monitoring system

•Relatively high radiation area (25 kGy at conduit over 30 years of operation)

→Radiation hardness of the system will be an issue, especially for the electric circuitry.

•A large scale system, which extends ~ 400 m.

•A resolution of 10 μm is sufficient, considering its effect on the orbit distortion.

Sensors

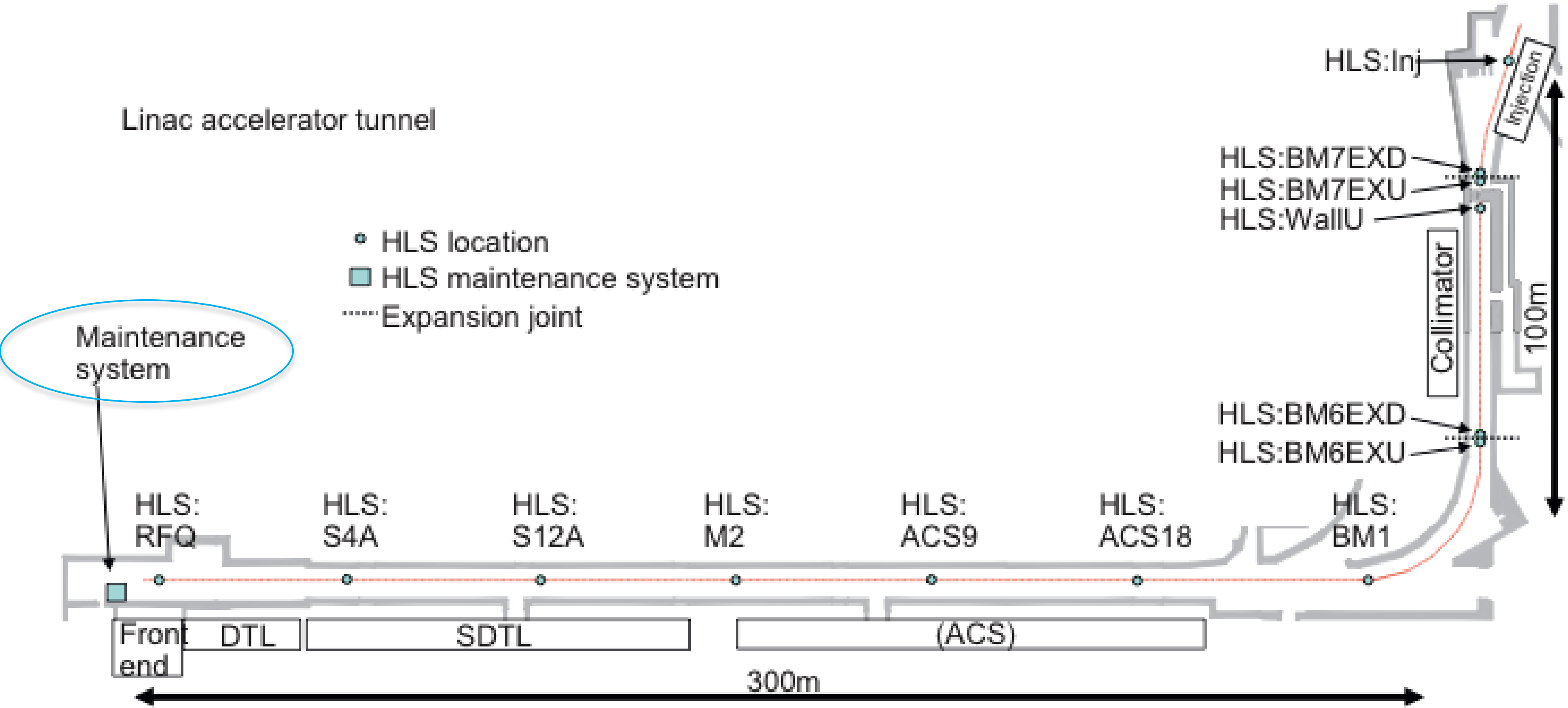
HLS
Fogale nanotech HLS capacitive sensors
HLS.REM 5/0-50
(4600€/sensor!)
full-filled type

Neighboring vessels are connected via Tygon tubing (TYGON 2275 I.B.) with an inner diameter of 19.05 mm.

Radiation hard for most parts of the linac,
except for the collimator and beam window (10 times higher)

Filled with purified water.

WPS
Fogale nanotech WPS -2D 10x10



330 m straight section running from north to south
a west-to-east 65 m collimator section.
13 sensors in the linac accelerator tunnel with intervals of about 50 m.

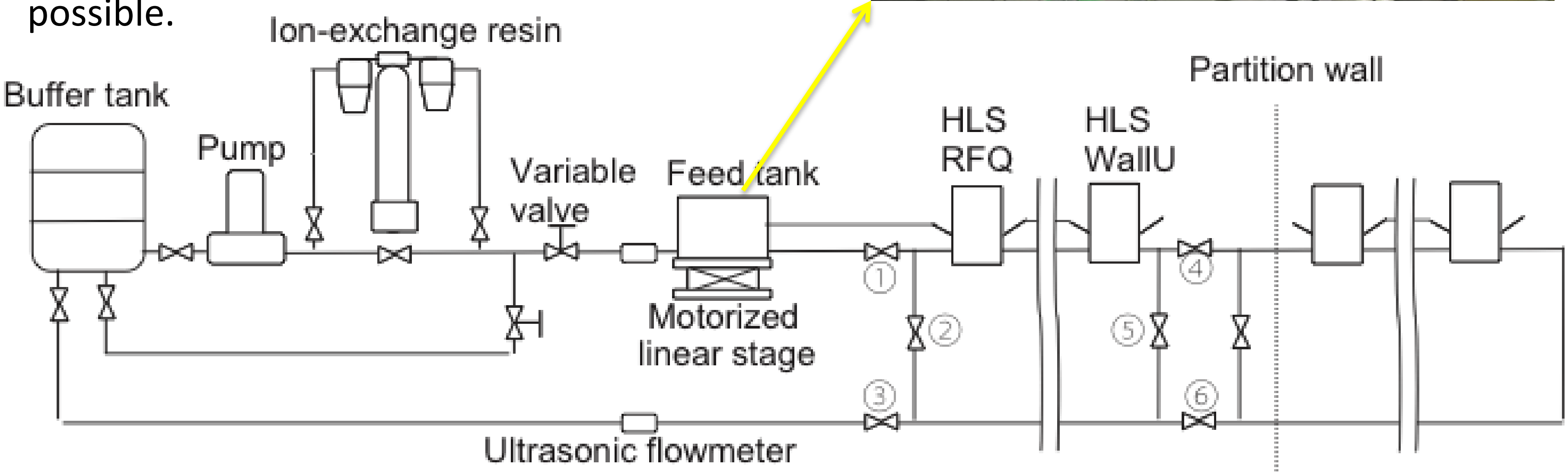
Temperature variation ~1 degree/day, ~ 2 degree over months
Temperature spatial variation ~ 2 degree.

Maintenance system

The average water level in the vessel can be shifted by moving a feed tank.

A water-level decrease of about 0.15 mm/day due to infiltration & evaporation has been observed.
Water feed once or twice/month.

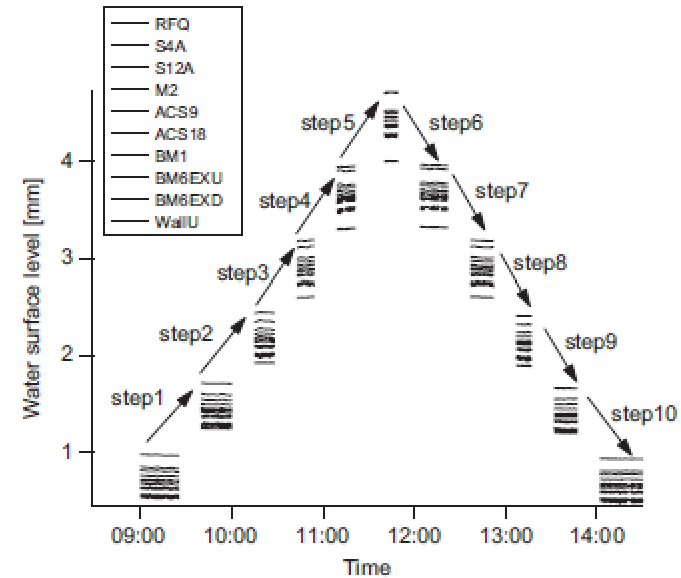
The expected total amount of water loss in 1 year is about 0.0056 m^3.
→more than 6 months of beam operation is possible.

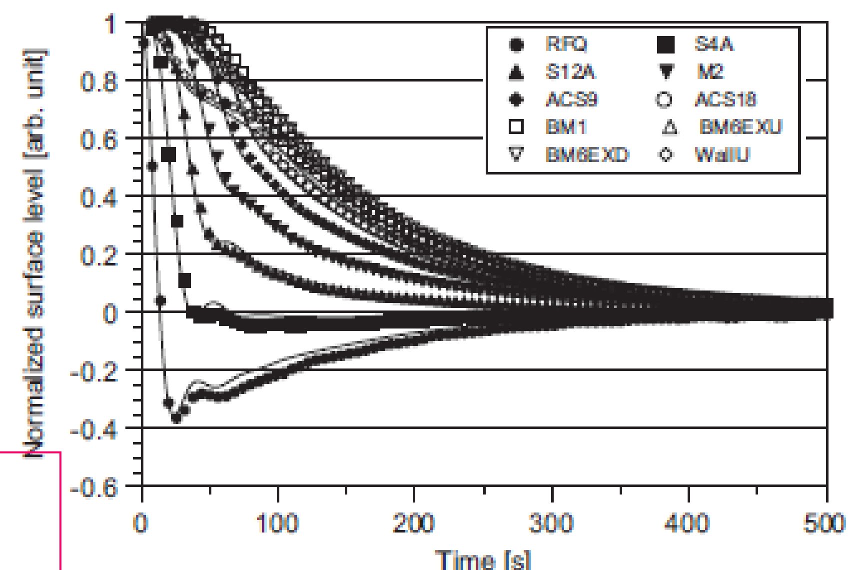


Online calibration

Forced variation test:
To ensure the communication among sensors.
To obtain the additional calibration to be multiplied by the factory-provided calibration curve.

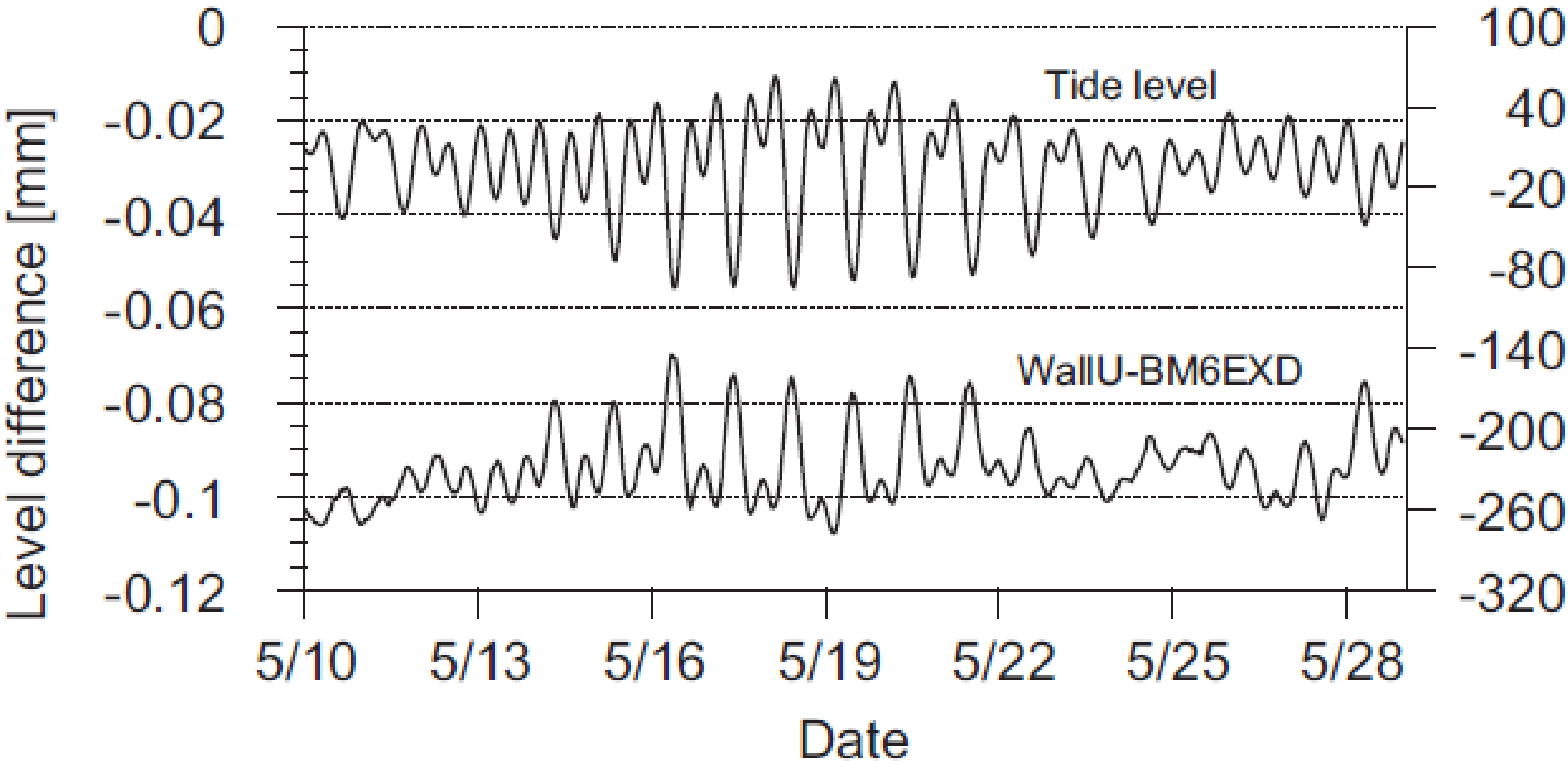
Filling test:
For obtaining the stabilization period, defined as the elapsed time until the maximum displacement of all sensors damps below 1% of the initial perturbation.
→540 seconds





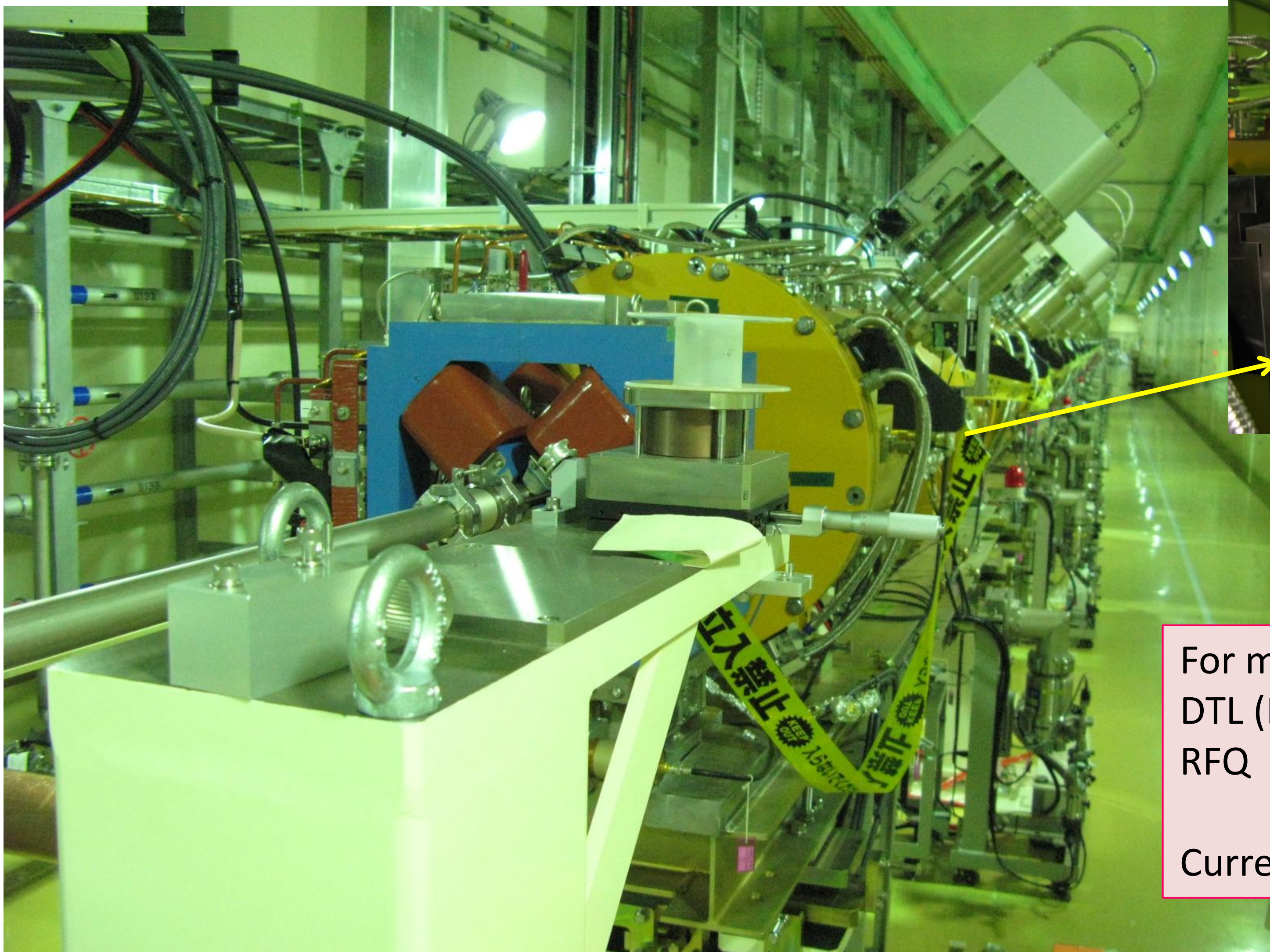
T. Morishita, M. Ikegami, Nucl. Instr. and Meth. A (2009)

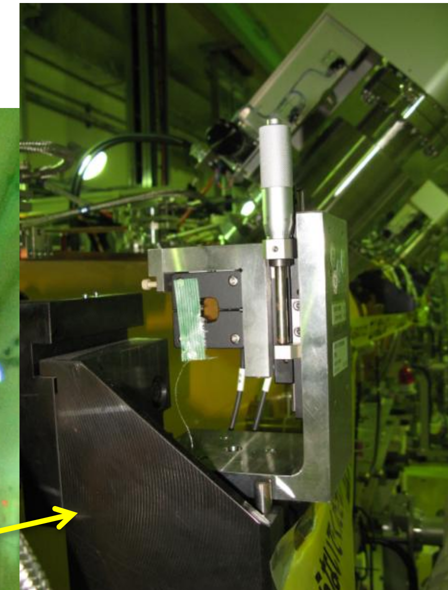
Slow ground motion observed at J-PARC linac



Relative water-level difference of two neighboring sensors and tidal level.
Data acquisition 1.5 seconds.
This monitoring system based on the hydrostatic leveling system is useful for monitoring the slow ground motion in J-PARC linac.
Tunnel deformation after the construction has not been too large.

WPS at J-PARC linac





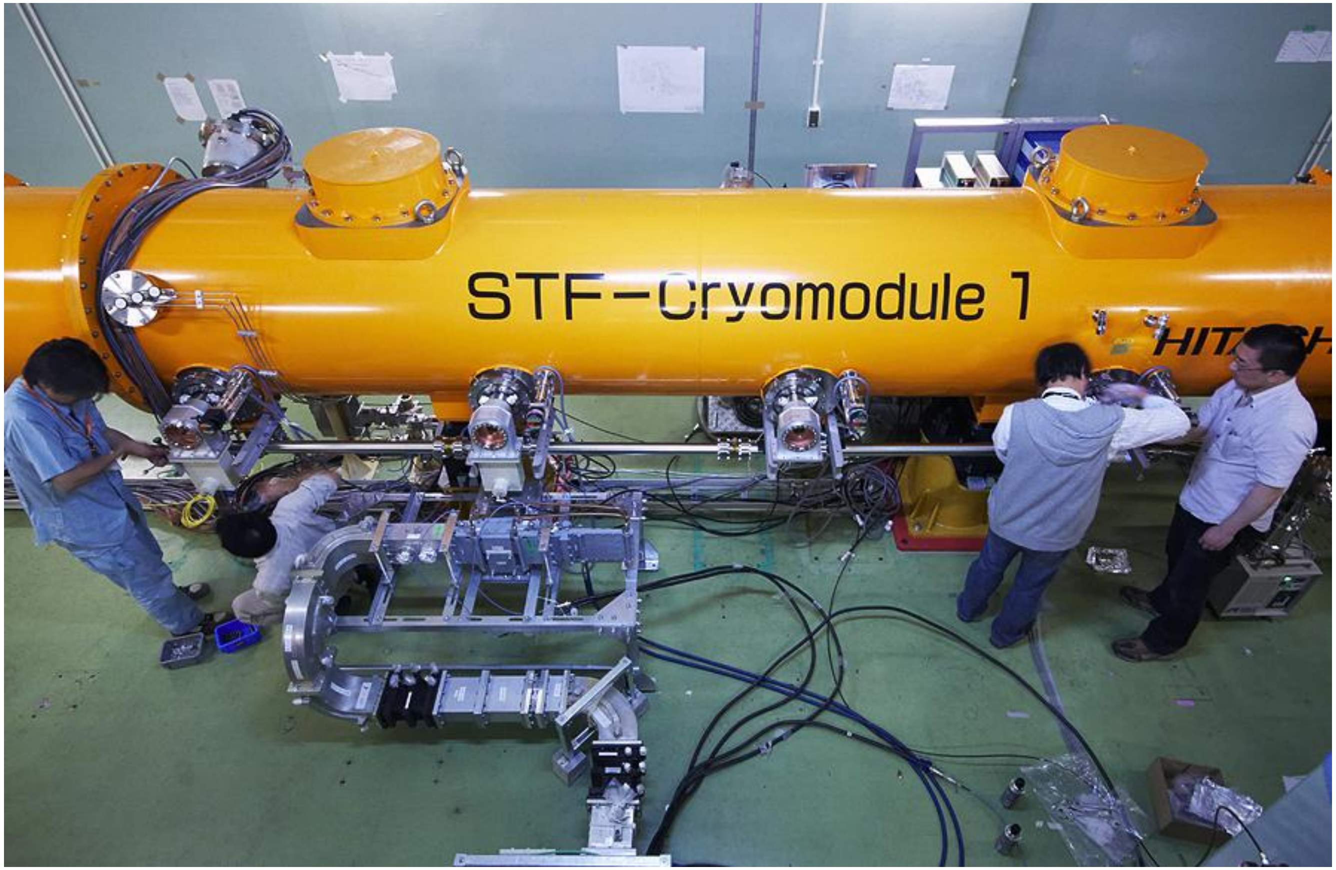
For monitoring
DTL (Drift Tube Linac)
RFQ

Currently not in use.

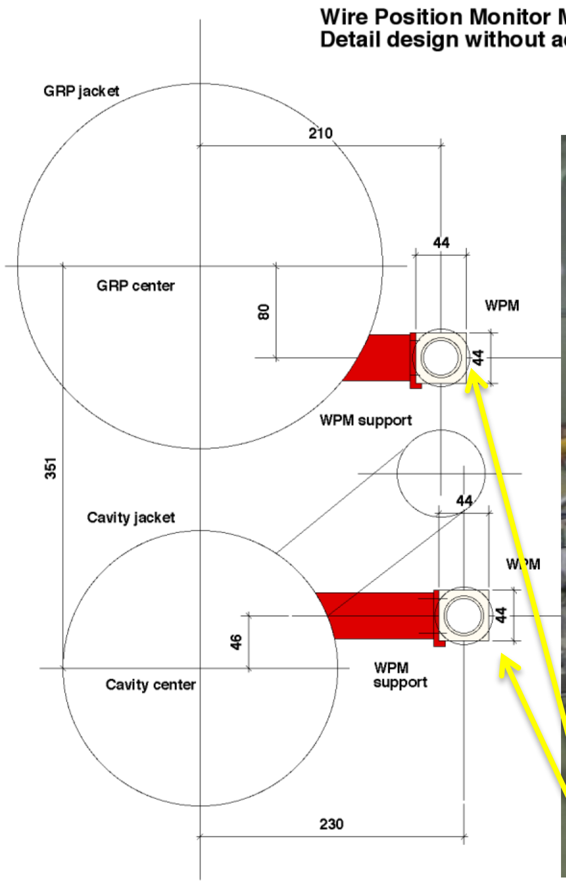
3. WPS at STF
(Superconducting RF Test Facility)

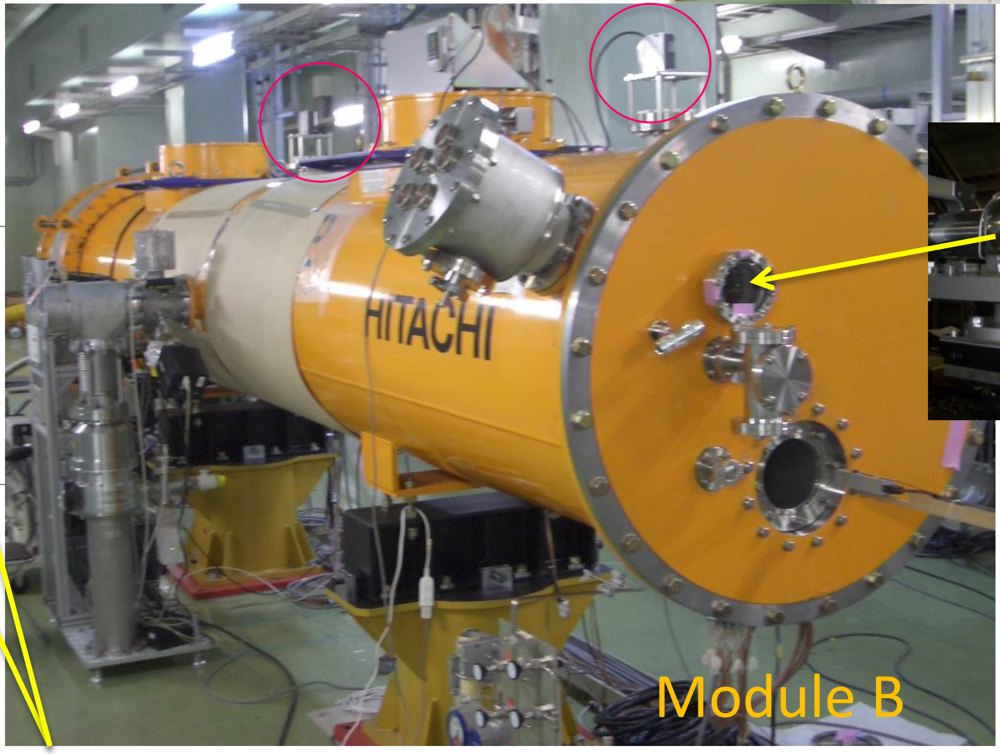
A project at KEK to build and operate a test linac with high-gradient superconducting cavities, as a prototype of the main linac systems for ILC.

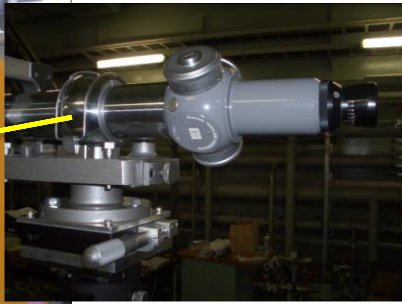
To establish a facility for domestic and regional development activities on superconducting RF (SRF) technologies.



WPS at STF





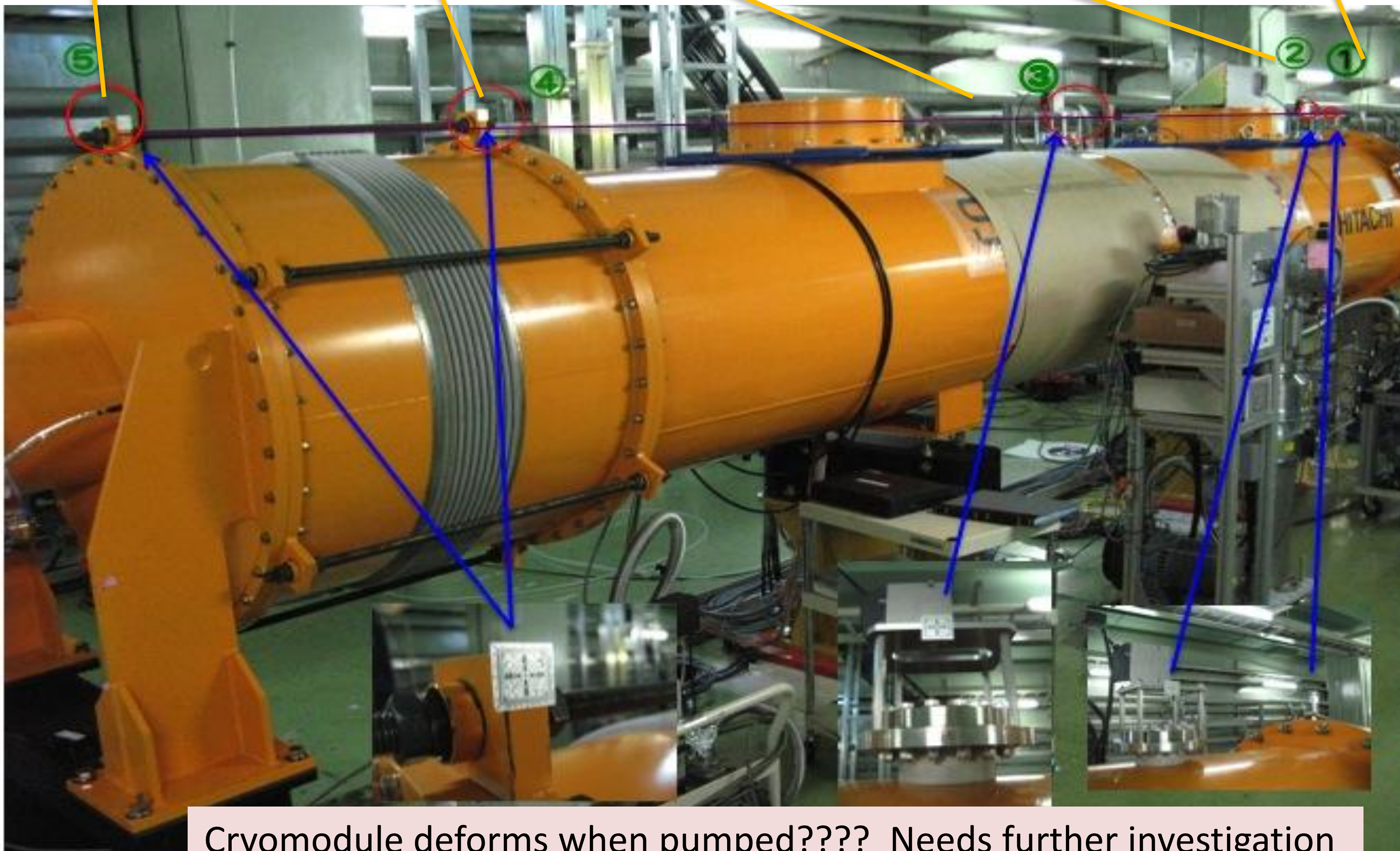


Purpose:
to see if cavities move when cooled down.
WPS outputs will be tested with optical scope next week.

Vertical position change: Before and after

NOT cool down but when vacuum pump was turned on!

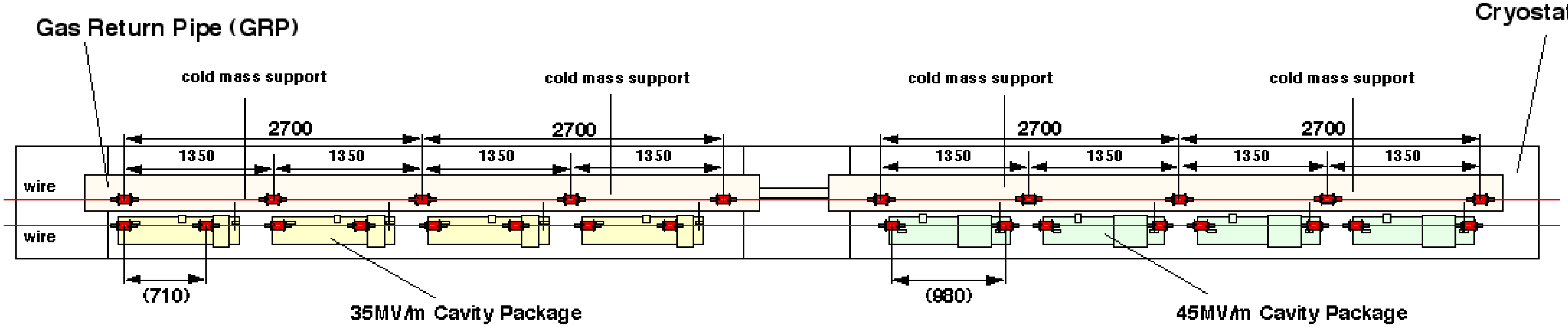
-0.07 mm -0.12 mm -0.08 m +0.01 mm +0.05 mm



Cryomodule deforms when pumped???? Needs further investigation

WPS at STF

WPM installation position



number of WPM: at GRP 5 + 5 = 10
at Cavity Jacket 2 x 4 + 2 x 4 = 16

total 26 (coax-cable 4 x 26 = 104)

H. Hayano 05222006

	Module A		Module A		Module B		Module B
ch1	GRP1	ch9	CAV1	ch17	GRP6	ch25	CAV9
ch2	GRP2	ch10	CAV2	ch18	GRP7	ch26	CAV10
ch3	GRP3	ch11	CAV3	ch19	GRP8	ch27	CAV11
ch4	GRP4	ch12	CAV4	ch20	GRP9	ch28	CAV12
ch5	GRP5	ch13	CAV5	ch21	GRP10	ch29	CAV13
ch6	no connection	ch14	CAV6	ch22	no connection	ch30	CAV14
ch7	no connection	ch15	CAV7	ch23	no connection	ch31	CAV15
ch8	no connection	ch16	CAV8	ch24	no connection	ch32	CAV16

Manufactured by local companies.

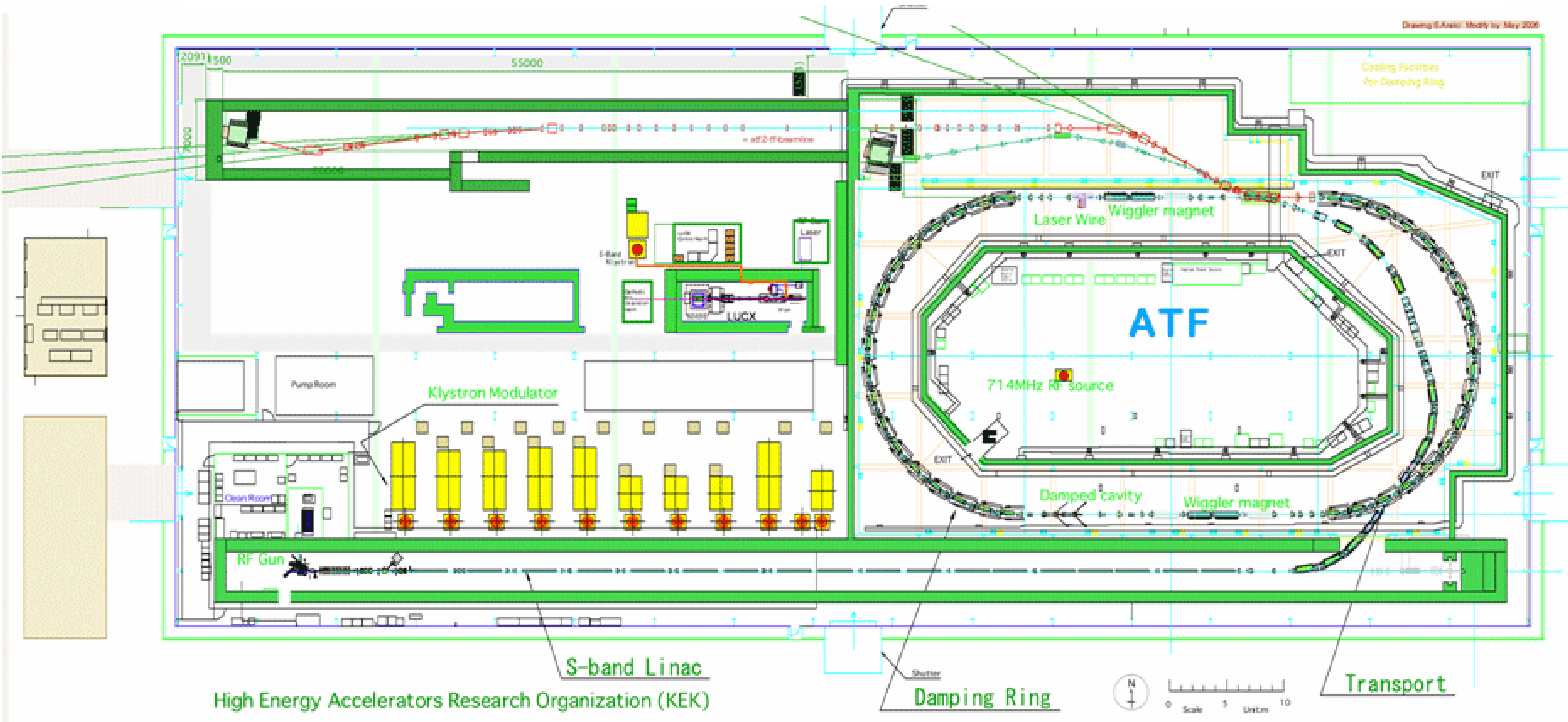
Currently being tested. Noise, cross-talk… not very reliable yet.

HLS/WPS potential installation locations at KEK

ATF2
SuperKEKB
STF

ATF2
(Accelerator Test Facility 2)

An international project to build and operate a test facility for the final focus system that is envisaged at ILC. The primary project goal is to establish the hardware and beam handling technologies pertaining to transverse focusing of the electron beams to nearly 40 nm.



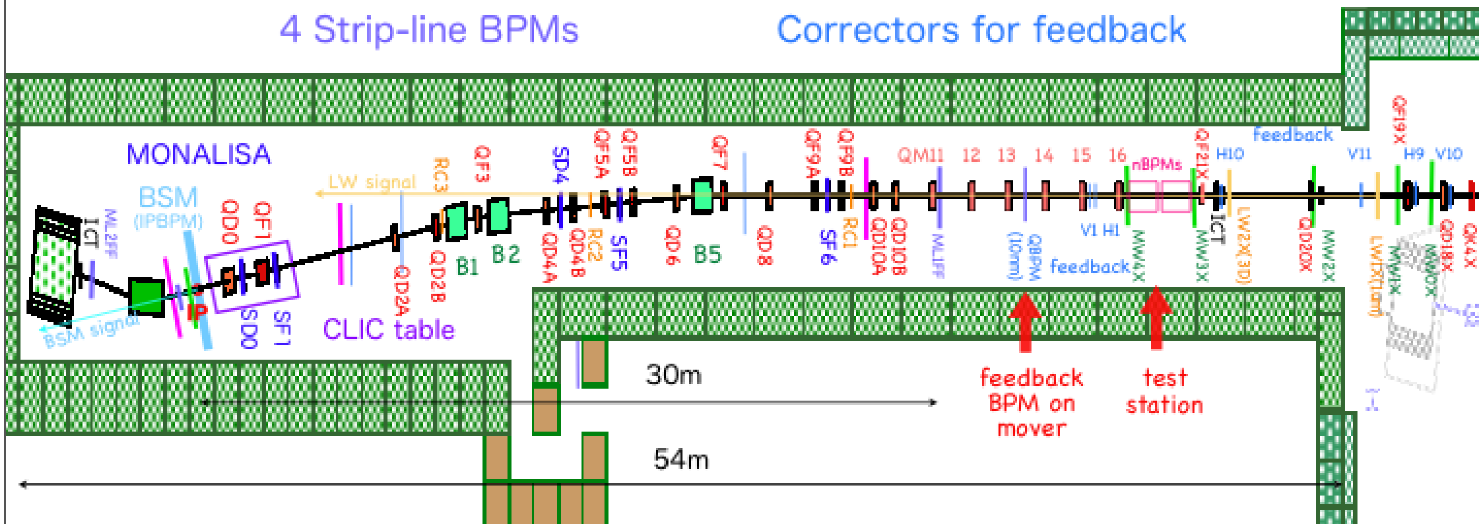
Magnets and Instrumentation at ATF2

22 Quadrupoles(Q), 5 Sextupoles(S), 3 Bends(B) in downstream of QM16

All Q- and S-magnets have cavity-type beam position monitors(QBPM, 100nm).

3 Screen Monitors — 5 Wire Scanners, Laserwires

4 Strip-line BPMs — Correctors for feedback



Shintake Monitor (beam size monitor, BSM with laser interferometer)

MONALISA (nanometer alignment monitor with laser interferometer)

Laserwire (beam size monitor with laser beam for 1 μm beam size, 3 axies)

IP intra-train feedback system with latency of less than 150ns (FONT)

Magnet movers for Beam Based Alignment (BBA)

High Available Power Supply (HA-PS) system for magnets

GM-measurements

- Vibration measurement with seismometers at new ATF2 beam line and comparison with that in the ATF Ring.
- Floor movement measurement with HLS system. ←
- Measurement of daily variation of the floor tilt.

KEK Homeworks

T. Tauchi

5th ATF2 Project Meetings
19-21 December 2008, KEK

Possibility of using HLS at ATF2

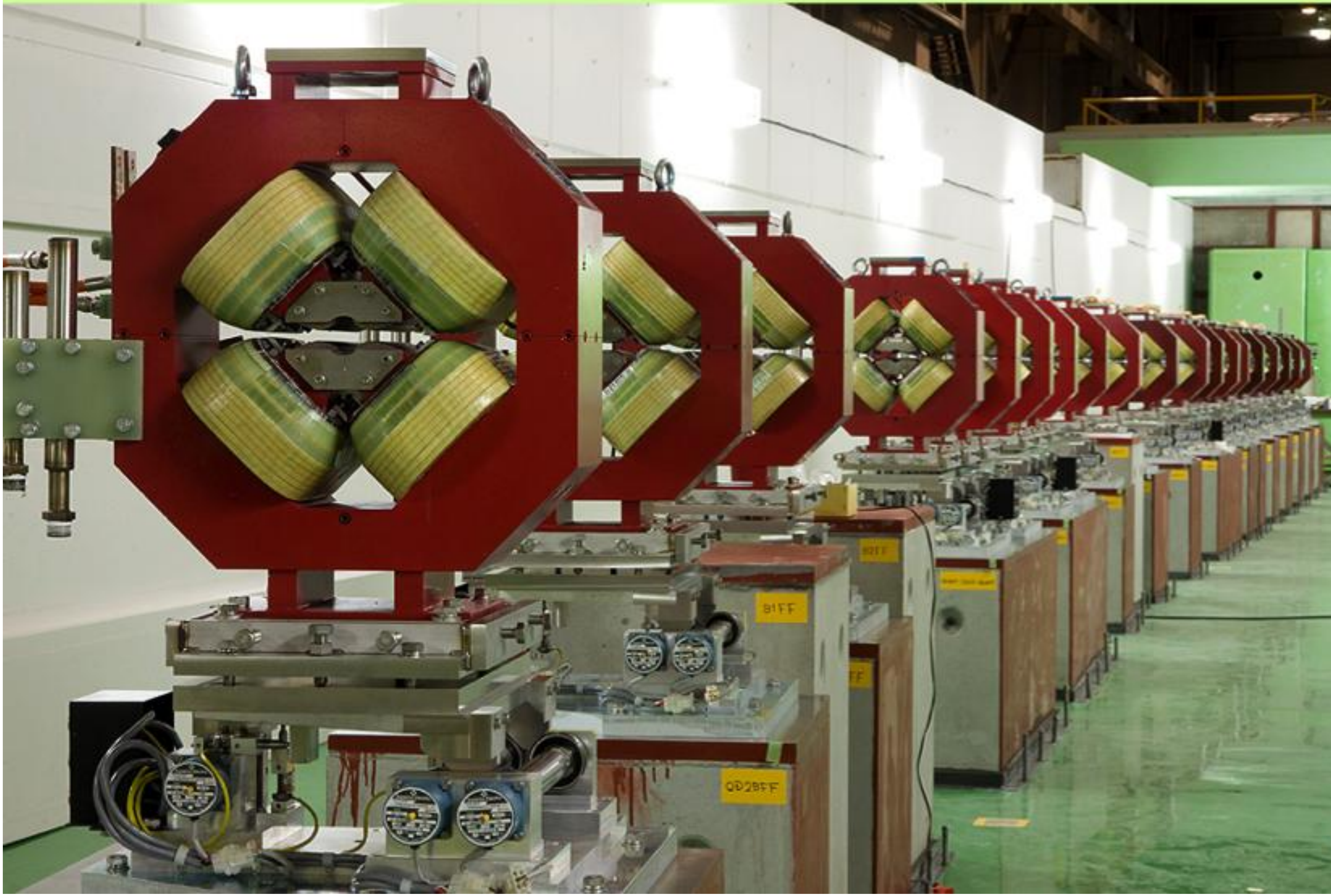
We discussed KEK home-work items which were raised at the 5th ATF2 project meeting, where C, Q and A are comments, questions and answers, respectively.

- Vibration measurements with seismometers at new ATF2 beam line and comparison with those in the ATF Ring.
- Floor movement measurement with HLS system.
- Measurement of daily variation of the floor tilt.

Since Sugahara has only 3 HLS systems, he will ask S. Takeda for more HLS systems.
At the project meeting, it was pointed out (by whom?? A. Seryi??) that FNAL has hundreds of HLS sensors. ⇦Is this true?

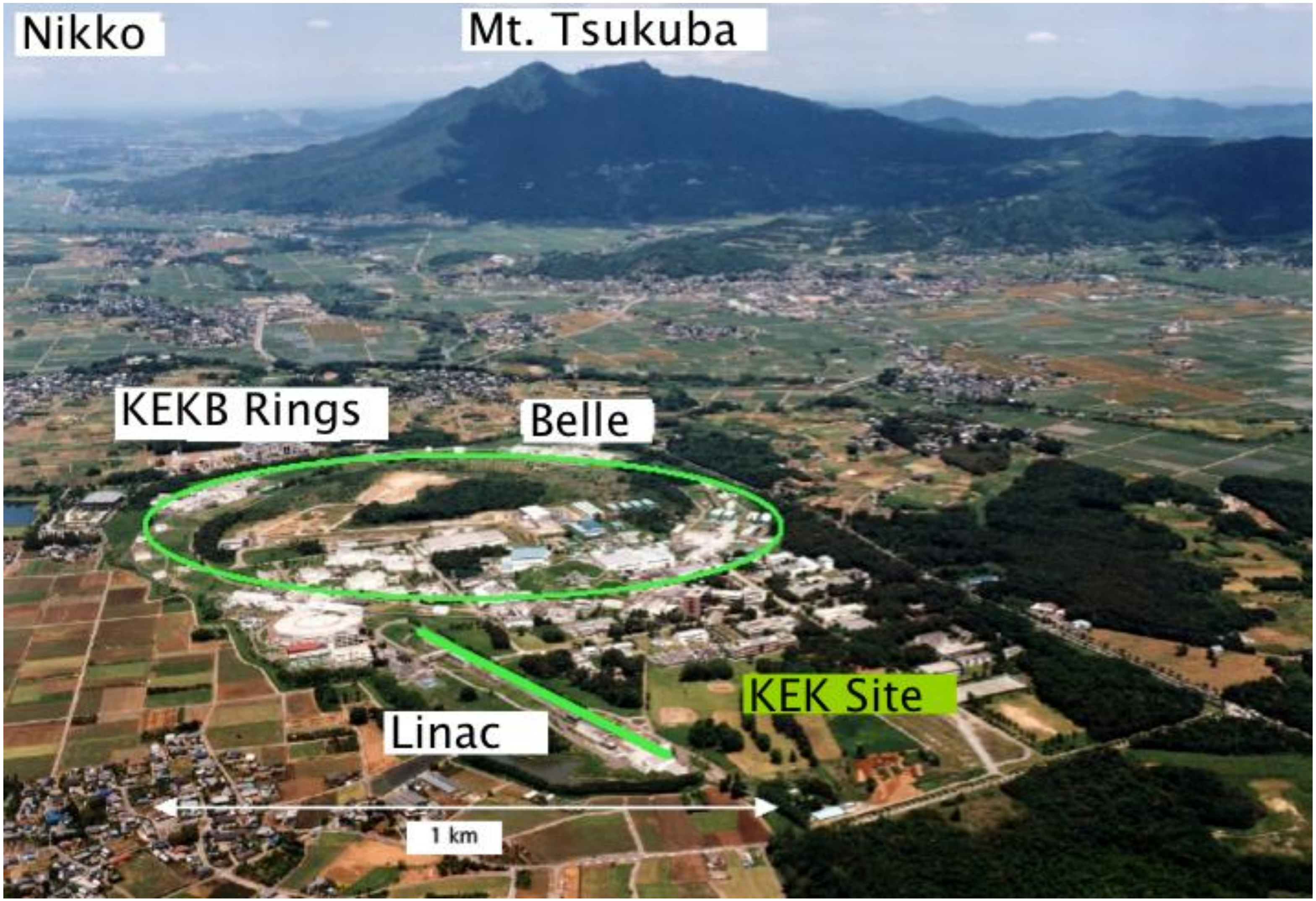
Collaboration with LAPP?

ATF2 Beam Line



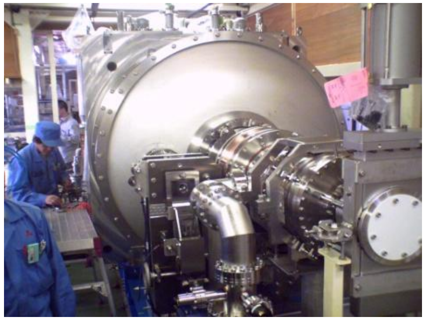
Possibility of HLS/WPS at SuperKEKB

SuperKEKB becomes nano-beam!?

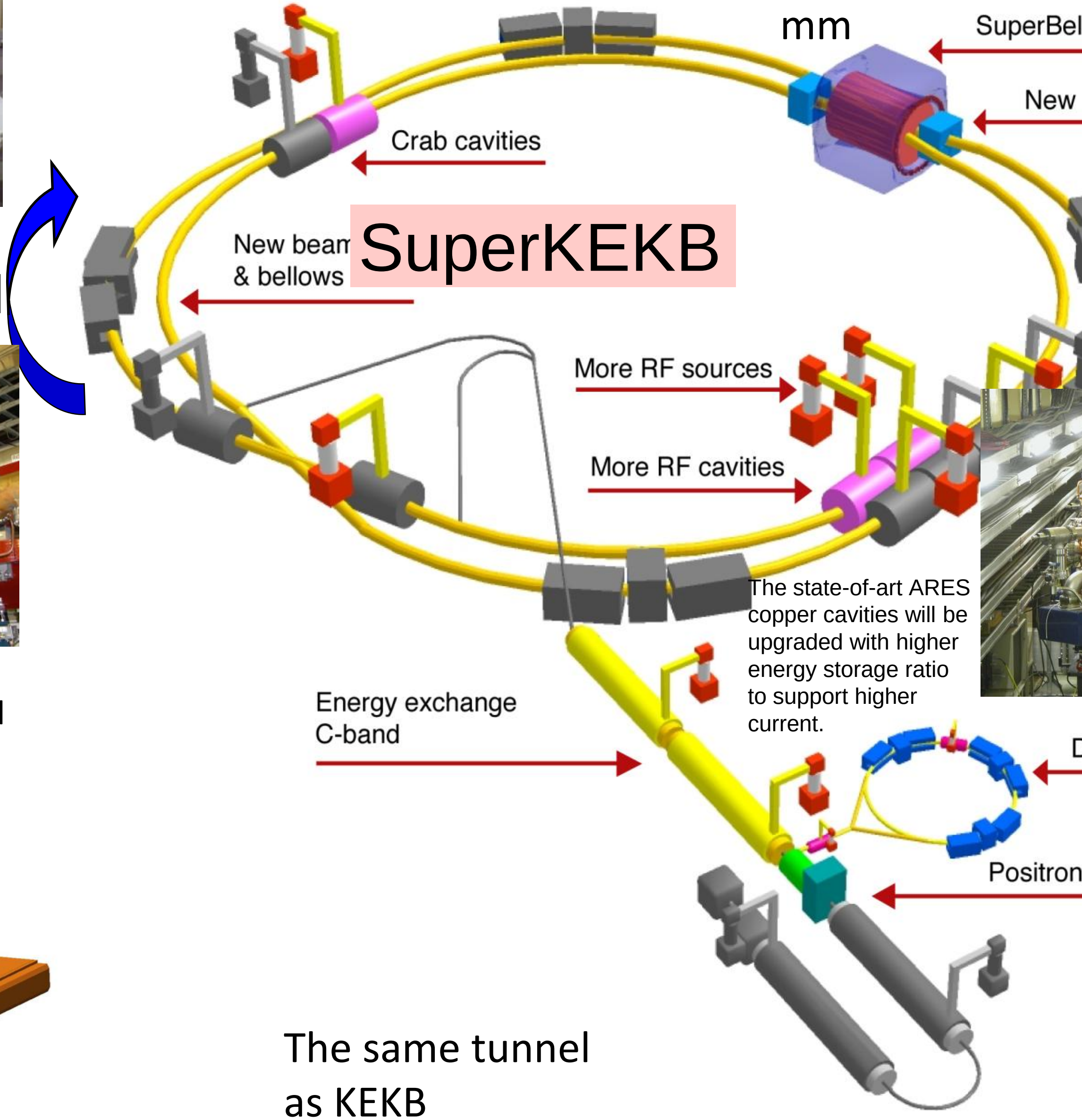


SuperKEKB

$\beta^*_y = \sigma_z = 3$ mm

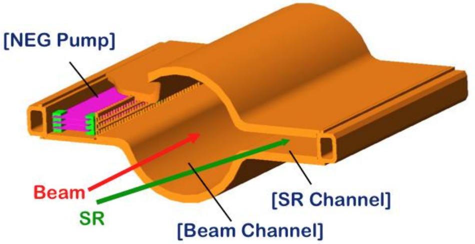


Crab cavity



The superconducting cavities will be upgraded to absorb more higher-order mode power up to 50 kW.

The state-of-art ARES copper cavities will be upgraded with higher energy storage ratio to support higher current.



The beam pipes and all vacuum components will be replaced with higher-current design.

The same tunnel as KEKB

3 km circumference, 11m below GL

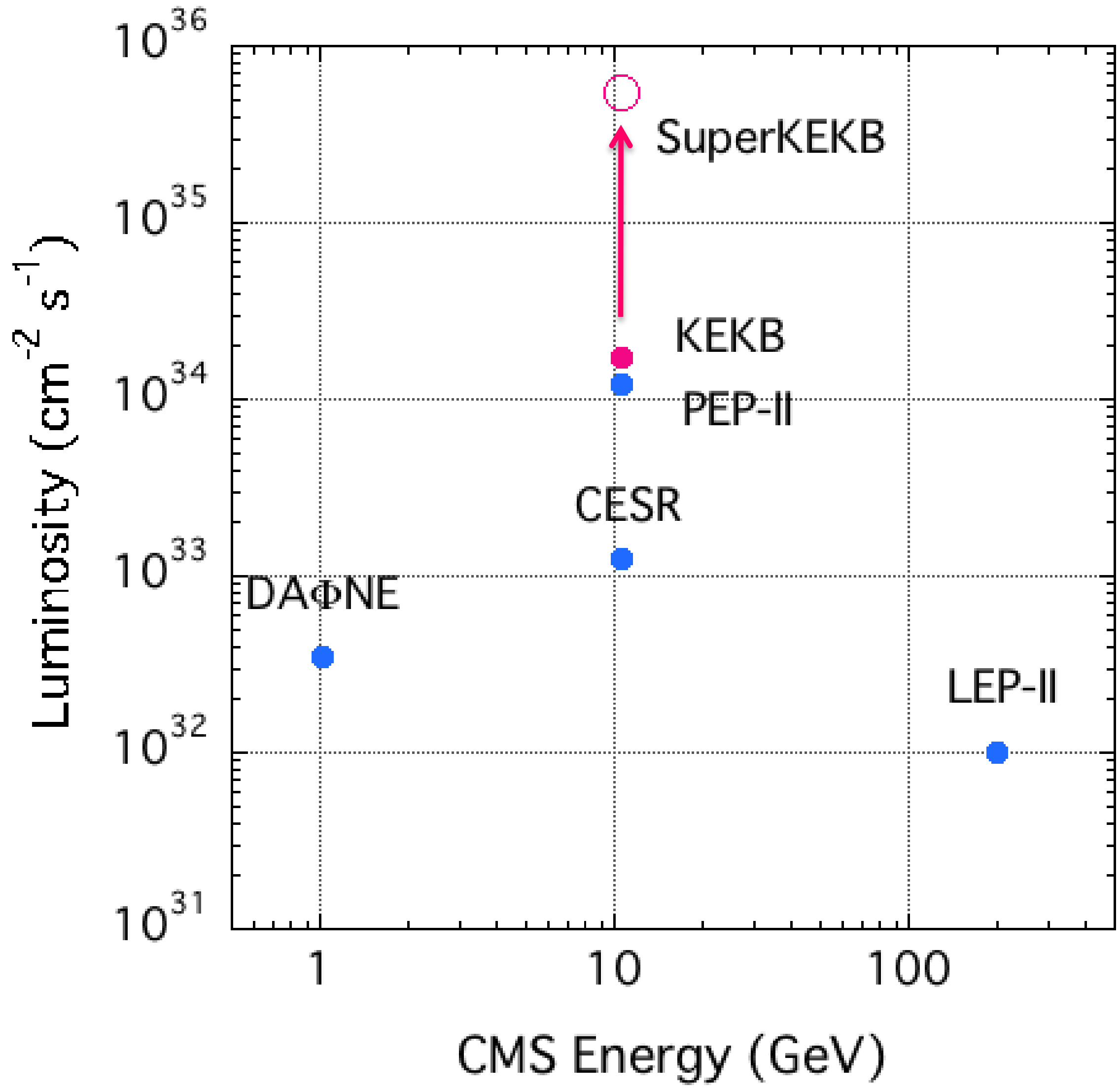
Table 1: Machine parameters of KEKB

Date	**11/15/2006**		**Design**		
	LER	**HER**	**LER**	**HER**	
Current	1.65	1.33	2.6	1.1	A
Bunches/ring	1389		5000		
Bunch current	1.19	0.96	0.52	0.22	mA
Bunch spacing	1.8–2.4		0.6		m
Emittance ε_x	18	24	18	18	nm
β_x^*	59	56	33	33	cm
β_y^*	0.65	0.59	1.0	1.0	cm
Hor. size @ IP	103	116	77	77	μm
Ver. size @ IP	1.9	1.9	1.9	1.9	μm
Beam-beam ξ_x	0.115	0.075	.039	.039	
Beam-beam ξ_y	0.101	0.056	.052	.052	
Bunch length	7	6	4	4	mm
Luminosity	17.12		10		/nb/s
$\int$Lum./day	1232		~ 600		/pb
$\int$Lum./7 days	7.82		–		/fb
$\int$Lum./30 days	30.21		–		/fb

70% higher than the design

doubled the design

Luminosity goal



Two options for SuperKEKB

MAC reviewers' comment:

Studies related to the nano-beam option be given high priority.

	High-Current	Nano-Beam
Stored Current(LER/HER)	9.4 / 4.1	$\sim$ 2.6 / 1.5
Equiv. emittance(LER/HER)	$\sim$ 20 / 20	$\sim$ 1 / 1
New arc magnets	None	LER dipoles + HER all
New beam pipes	LER/HER	LER/HER
More RF stations?	Yes	No
Luminosity	4	8 10^{35}

A decision will be made in about 6 months.

Hardware Impacts of nano-beam option

Tolerances on stability of position-sensitive components such as magnets, BPMs will be much more demanding, particularly in the IR.

- Floor/magnet vibration
- How to monitor & maintain a good collision, etc.

Parameters for Super B Factories

a) b-b simulation, b) geometrical

	SuperKEKB	SuperBunch T	SuperBunch H	Super B	Super B New
εx (nm) (L/H)	24/18	1/10	1/10	2.8/1.6	2.8/1.6
εy(nm)	0.24/0.09	0.0035/0.025	0.0035/0.025	0.007/0.004	0.007/0.004
κ (%)	1/0.5	0.35/0.25	0.35/0.25	0.25/0.25	0.25/0.25
βx (mm)	200/200	35/20	35/10	35/20	44/25
βy (mm)	3/6	0.35/0.22	0.35/0.22	0.22/0.39	0.21/0.37
σx (μm)	69/60	5.9/14	5.9/10	9.9/5.66	11/6.32
σy (μm)	0.85/0.73	0.035/0.071	0.035/0.071	0.039/0.039	0.038/0.038
σz (mm)	5/3	6/6	6/6	5/5	5/5
φσz/σx	0/0	31/13	31/18	14/25	14/24
σx/φ(mm)	∞/∞	0.21/0.47	0.20/0.33	0.35/0.20	0.37/0.21
ne	5.25×10^{10}	3.89×10^{10}	8.11×10^{10}	5.52×10^{10}	5.99×10^{10}
np	$12.\times10^{10}$	6.78×10^{10}	1.39×10^{11}	5.52×10^{10}	5.99×10^{10}
I_{beam} (A)	9.4/4.1	2.70/1.55	2.65/1.55	1.85/1.85	2.0/2.0
#bunch/Cir(m)	5000/3016	2500/3016	1200/3016	1251/1800	1251/1800
φ (mrad) (half crossing angle)	0	30	30	24	30
ξy	0.30/0.51	0.067/0.068	0.139/0.139	0.147/0.150	0.125/0.126
Lum	5.3×10^{35} a)	5.0×10^{35} b)	10×10^{35} b)	11×10^{35} b)	10×10^{35} b)

Optics design still not finalized.

IR challenges

β_x^*=40 cm
as there is no realistic solution for 20 cm.

Difficulties with IR Design

- Limited space
- background-sensitive detector
- Low beta for higher luminosity
- high currents

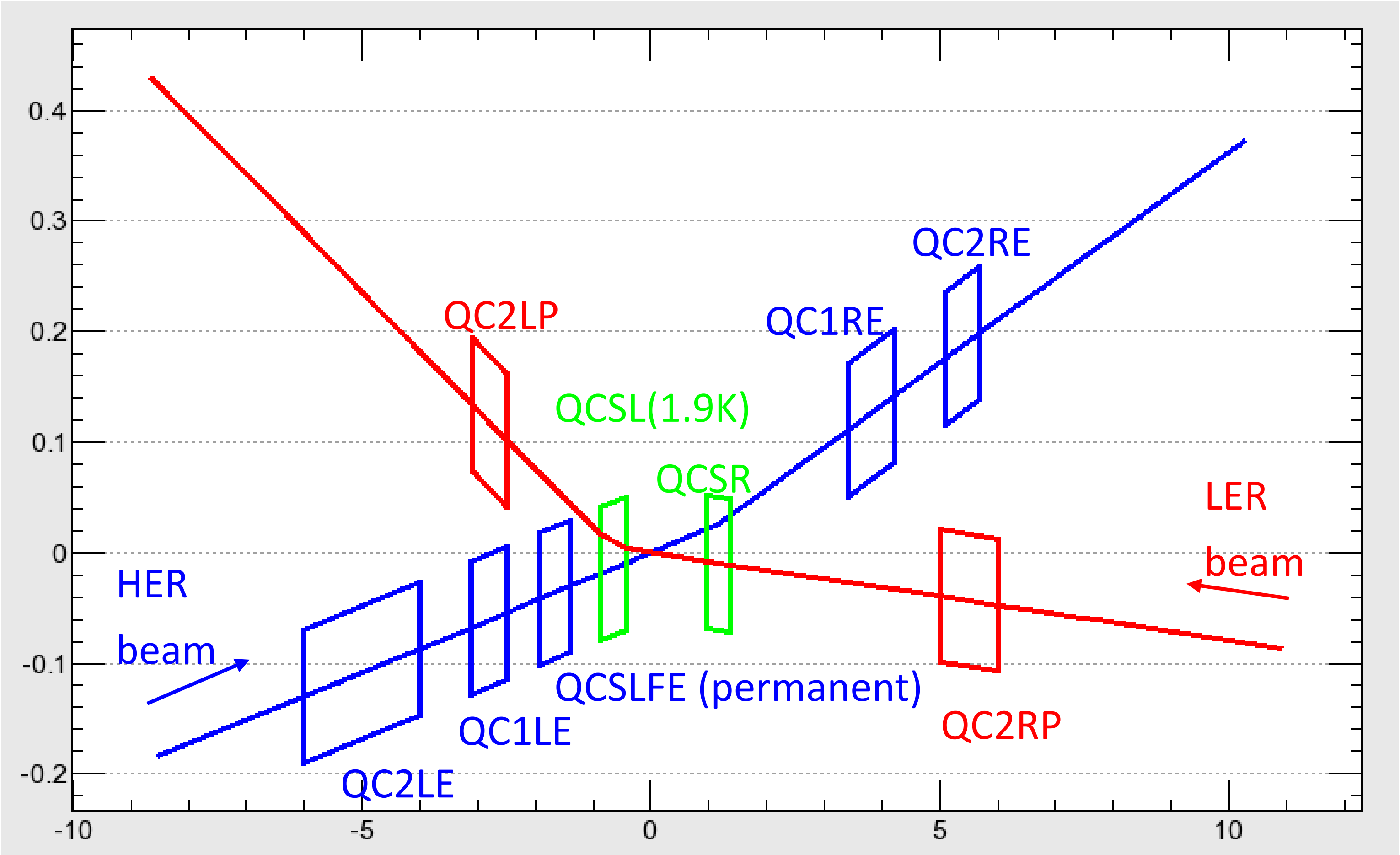
Requirements

- Physical aperture
- power deposition locations
- beam separation
- magnet strength

QC1 & QC2 superconducting
and
permanent magnet to give extra focusing in a congested space.

Soon the IR lattice design will be merged with the whole ring lattice.

IR magnet layout for new Optics



β_x^*=40 cm with QCSL (1.9K) and QCSFE (permanent)

Nano-beam option Issues

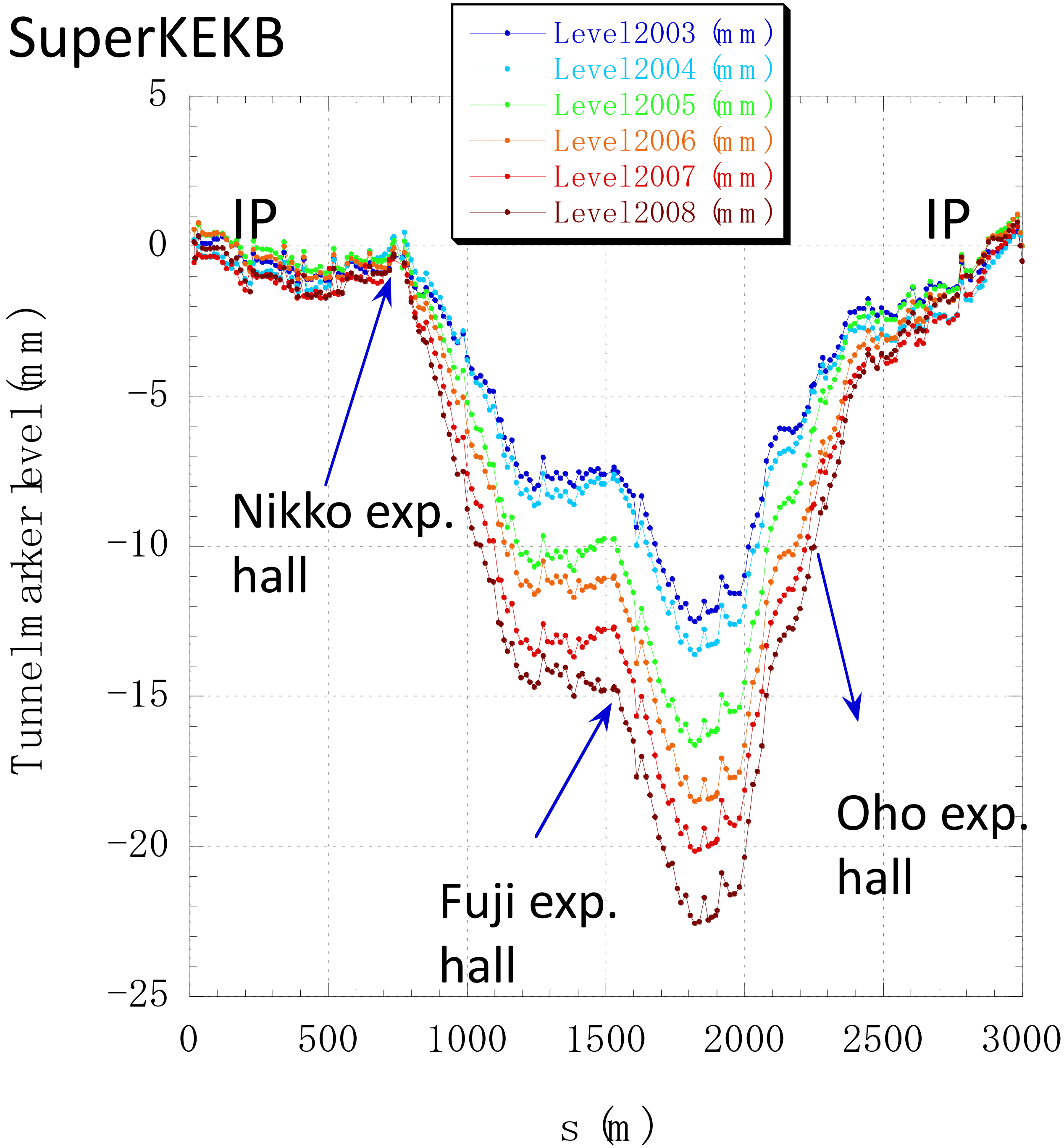
Potential "showstoppers"

- IR:
  - IR magnets 20-40 cm away from the IP.
  - Belle boundary
  - Beam separation
  - Compensation solenoids
  - Detector noise
  - others
- Final Focus/Local Chromaticity correction:
  - Re-do the Tsukuba straight section completely.
  - Modification of the arc section, which might include giving up on the TRISTAN magnets.
  - SSC wigglers?
- Injection:
  - Emittance, damping ring, electron gun, injection point.
- Stability (orbit, magnets, tunnel, BPM, collision), especially at the IP!
- Electron clouds, ion instability, precision of the feedback system.
- Energy ratio:7 GeV + 4 GeV?
- others

Possible gain @ SuperKEKB

Syrvey €18000
One data set
10 years

HLS for instance
Continuous
Real time
system



Summary

Some examples of HLS/WPS at KEK/JAERI:

- J-PARC
- STF

Begun consideration of new systems (HLS, for instance):

- ATF2
- SuperKEKB
- STF

Goal:

Integration with the beam operation

R&D for lowering the cost will be essential for installation for larger complex such as SuperKEKB.