Main Ring Magnets

M.Masuzawa

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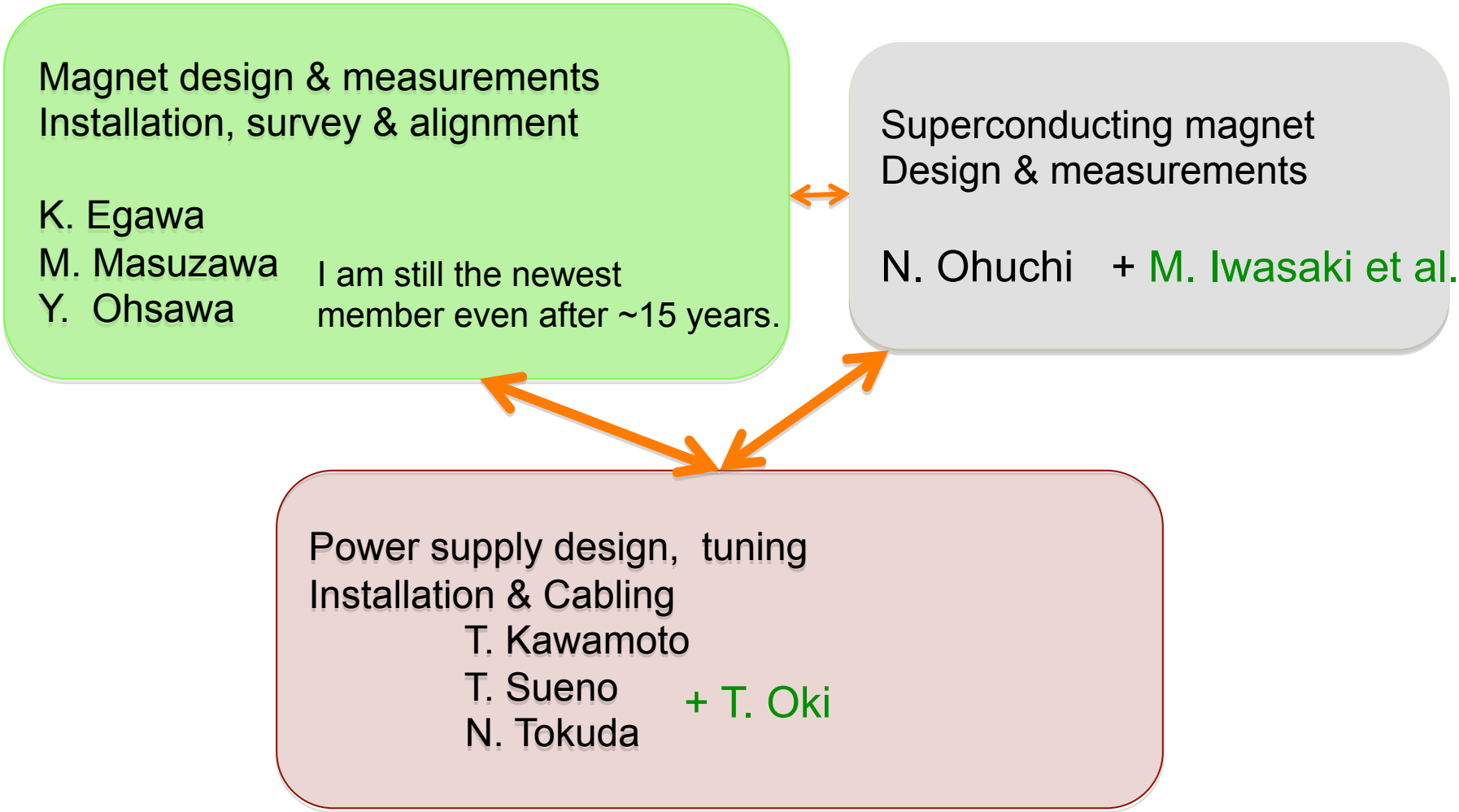
2. Magnet design & fabrication Status
3. Dismantling Status
4. Survey & Alignment Status
5. Other issues
6. Summary
7. Power Supplies
   by T. Oki

1. Overview


Magnet design & measurements
Installation, survey & alignment
K. Egawa
M. Masuzawa
Y. Ohsawa
I am still the newest member even after ~15 years.
Superconducting magnet
Design & measurements
N. Ohuchi + M. Iwasaki et al.
Power supply design, tuning
Installation & Cabling
T. Kawamoto
T. Sueno
N. Tokuda
+ T. Oki

“3/3” Nano-Beam Scheme

- LER vacuum pipes need to be replaced by new ones with ante-chambers.
  - ➔All LER quadrupoles and sextupoles need to be opened up (& put back together).
- LER main arc dipole magnets need to be replaced.
  - ➔From Leff 0.89 m ⇒4.19 m
- More wiggler magnets with shorter pole length.
  - ➔Different wiggler layouts to achieve shorter wiggle period.
- Completely different LER/HER beam lines in the Tsukuba straight section.
- New wiggler section needs to be added in the HER.
- Vertical steering magnets need to be replaced by wider ones in the LER.

“3/3” Nano-Beam Scheme

- Alignment strategy
  - Connecting the existing beam lines with the new beam lines (Tsukuba straight sections)
  - New IR magnet system

    ➔working closely with the IR group (N.Ohuchi et al.)
  - IR movable table needs to be newly designed.
- Cooling water system needs to be strengthened especially for the wiggler sections (Nikko and Oho straight sections) as we are operating the cooling water system at almost 100% capacity level already.

  ➔The utility group (M.Ono et al.) is in charge of the cooling water system upgrade.

2. Magnet design & fabrication Status

More than 400 new main magnets needed and measured by T=0, to circulate beam in the rings

Calls for bids for LER dipoles, wigglers and some other quads have been sent out. They will be made by the end of Mar. 2012.

Specifications not finalized for some of the Tsukuba straight section magnets.

LER

#	leff	k	mag.name	B, B' or B"	comment
2	0.3444	-0.000592	BC1LP	-0.022935	new
10	3.9896	0.043706	BL0&7,BS2	0.14617	new B.lc
14	4.189544	0.0799998	BL1~5,9	0.25478	new B.arc
100	4.189544	0.0560999	B2P	0.17866	new B.arc
112	0.2134	0.01118	BW0NRP.1	0.69902	new half_pole_WH
56	0.34347		BW3NRP.1		new single_pole_WS
10	0.31374	0.000993	QKALP	0.04223	new
37 + 16	0.58372	-0.3274108	QC3LP	*-7.4839*	LER_Q_rf + new
8	0.334		SL		new
328					

HER

#	leff	k	mag.name	B, B' or B"	comment
14	4	-0.04	BL1LE	-0.26685	LER new B.lc
7	0.3444	0.0034541	BC*	0.26763	new
1	0.3723	0.0019022	BC3LE	0.13634	new
38 + 22	0.3462		BW2ORP.1		_kb_wigg + new
6	0.3444	0.0001669	QKALE	0.012932	new
2	0.3723	-2.77E-05	QKDLE	-1.99E-03	new_Qsk
43	0.56	0.3345958	QC3LE	*15.944*	new_wide ? *(kb_Qarc)*
2	1.12	-0.6670868	QL9LE	-15.894	new wide ? *2×0.56m*
200 + 7	0.82615	-0.326735	QSATLE	-10.554	kb_QA 199+2 + new
4	0.334	0	SO2TLE.1		new or kb_SxF
108					

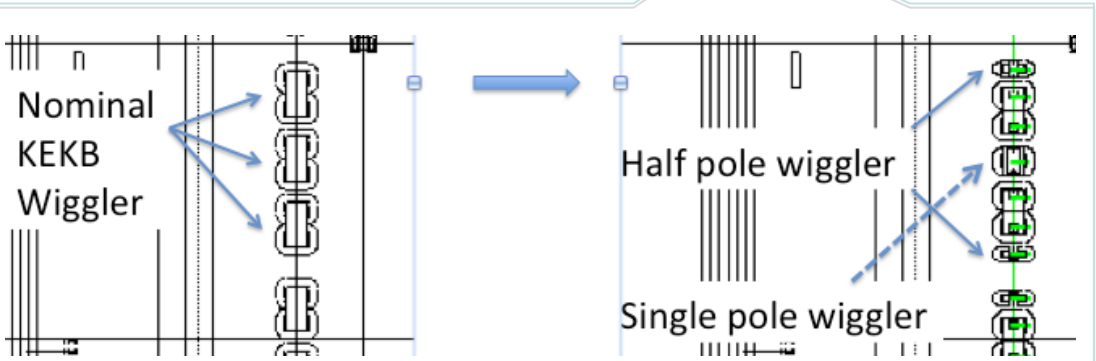
LER arc dipoles & new wigglers parameters

Magnet type	Mag. name	L_{eff} [m]	B[T]	counts	Comparison with KEKB
Arc dipole	B2P.1~100 BL(1~5)R/LP	4.1895	0.17866 0.25478	100 14(+2)	Longer, weaker LER Local correction
Local correction	BL*R/LP	3.9896	0.14617	24(+2)	LER/HER Local correction
Wiggler	BW0*.P	0.2134	0.69902	112(+2)	Half pole
Wiggler	BW1*.P	0.34347	0.69902	56(+2)	Single pole

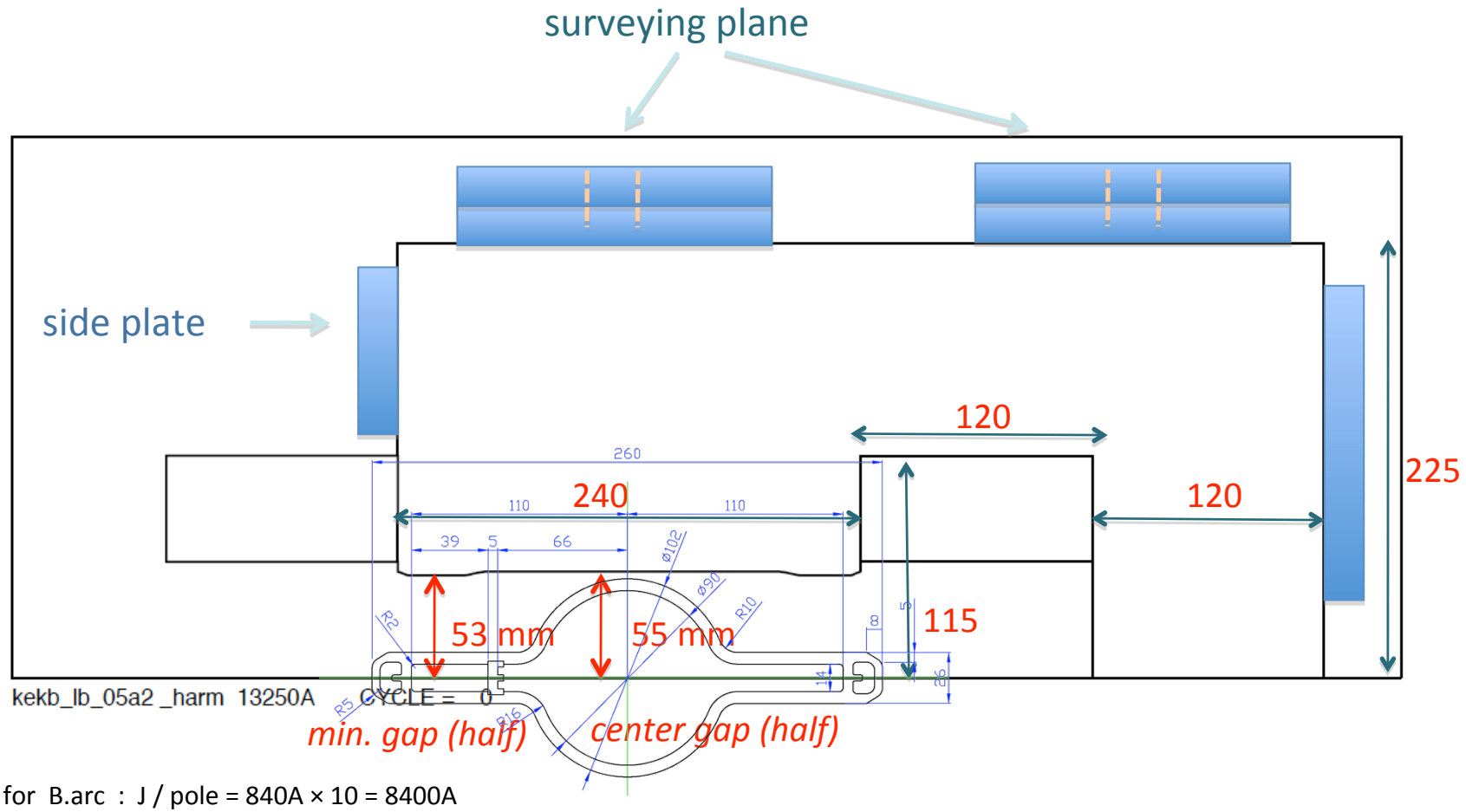
Why not the same length, to make fabrication (and contract) simpler?

Arc dipoles, as long as possible! from the emittance point of view.

But they are ~20cm too long to fit in the new IR straight sections.



LER Dipole maget



for B.arc : J / pole = 840A × 10 = 8400A
for B.lc : J / pole = 1325A × 10 = 13250A / pole

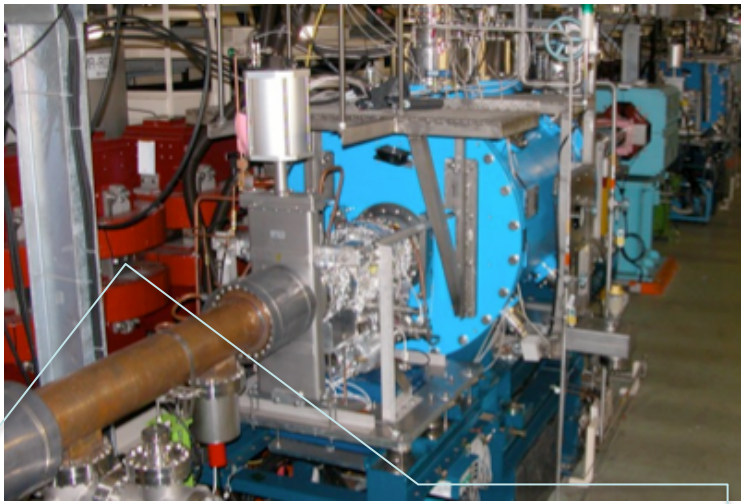
pole profile unit [mm] (preliminary)

x coordinate :	-120.	-115.	-85.	-75.	78.	88.	115.	120.
y coordinate :	55.	53.	53.	55.	55.	53.	53.	55.

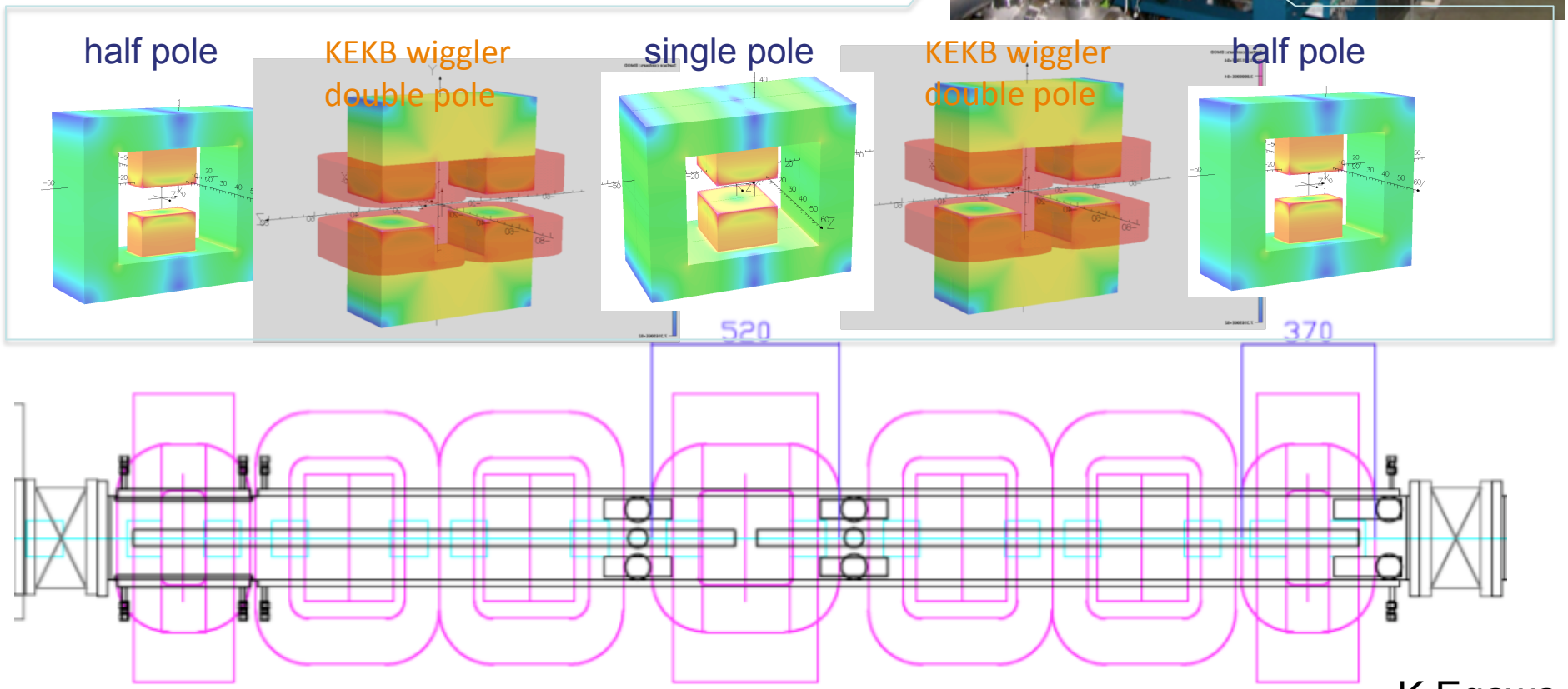
beam pipe and the cross section of new LER dipole

K.Egawa

Wigglers



- Reduce wiggling pitch ⇨ 1/2
- Increase KEKB type wiggler peak field
  0.77 T ⇨ 0.98 T
- New wigglers (“half pole” and “single pole”, both window frame type) must fit in the very tight space (transverse direction)



K.Egawa

Steering magnets

to be manufactured & measured
or to be modified for SuperKEKB

Magnet type	Mag. name	Eff. length [m]	B·Leff [T·m]	counts	Comments
LER Vertical for arc sec.	ZV*P	0.344+α	~0.012	Only for QD ~210	Wider gap for antechamber 160 ⇒ ~290 mm
LER Horizontal for arc sec.	ZH*P	0.344	0.02	Only For QF ~210	Rotate LER ZV*P by 90° new supports
HER Vertical for arc sec.	ZV*E	0.344+α	0.02?	Only for QD ~290?	Wider gap for antechamber 160 ⇒ 240 (?) mm
HER Horizontal for arc sec.	ZH*E	0.344	0.03	Only For QF ~210	Rotate HER ZV*P by 90° for wider good field region new supports

KEKB quads were accompanied by both vertical and horizontal steering magnets.
But SuperKEKB quads will only have one type to reduce cost.
Power supplies for corrector magnets will be reused to reduce cost.
The price we pay is the kick angle.

Max. kick will be 0.012/0.02×3.5/4 (~0.5) for ZV*P.
Max.kick will be 3.5/4 for ZH*P.

>200 new cor. magnets
>400 new supports

3. Dismantling Status

Introduced by Akai-san yesterday

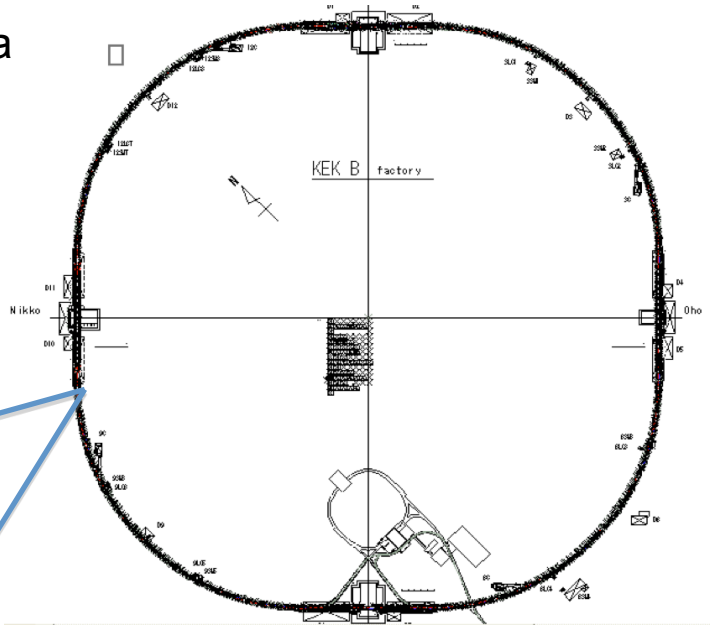
Been busy

Main work in the KEKB tunnel

	~Sep. 2010	Oct.	Nov.	Dec.	Jan. 2011	Feb.	Mar.
LER B removal							
Wiggler removal							
Steering removal							
Vacuum pipe removal (open&close Q & Sx)							
Others Air pallet overhaul Designing new tools							
Draining cooling water from the magnets to be reused.							

Oct. 28, 2010 Dismantling started officially

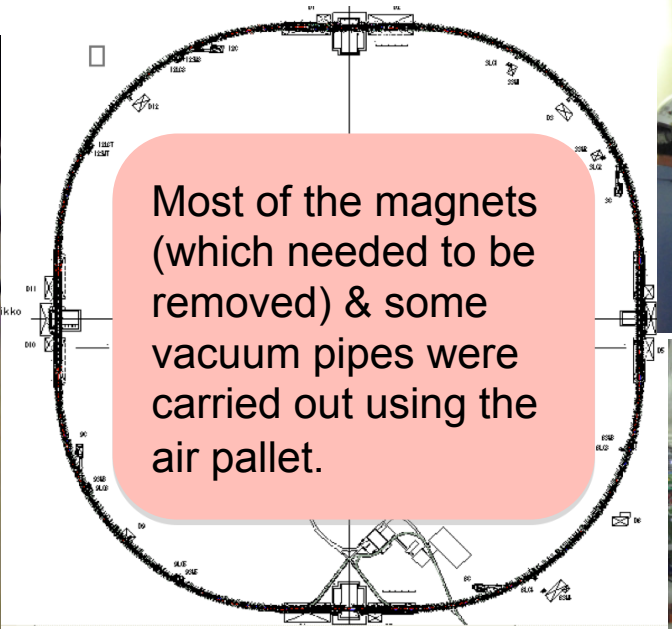
Aug.21st , 1998 Former director general H. Sugahara tightening the gold-plated bolt (of the last magnet)



Oct.28th ,2010
Director General A.Suzuki, Accelerator Division Director K.Oide and others, loosening the bolts of the same magnet.

Air pallet in full action

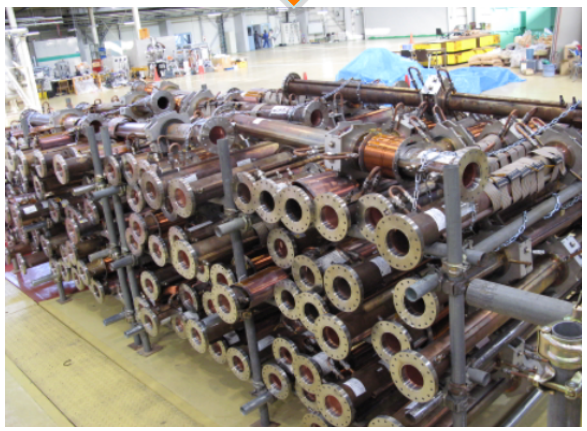
1st magnet carried out by air pallet on Nov. 11th ,2010



Most of the magnets (which needed to be removed) & some vacuum pipes were carried out using the air pallet.

Working in between the inner (remaining) HER beam line & the cable racks at the Nikko cavity section. We did take them out.

The magnet group has carried out 342 vacuum pipes so far (mostly those inside magnets), each probably ~2m long and more than 40 kg.



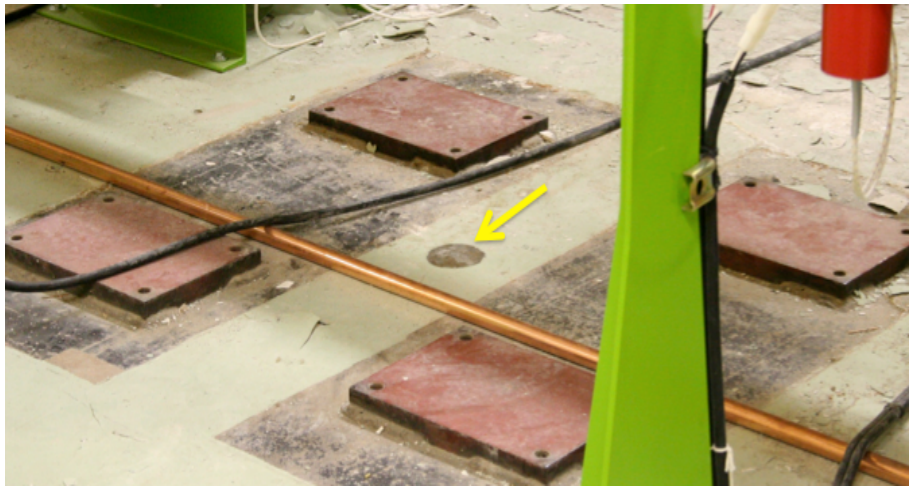
Less crowded & much lighter tunnel and much more crowded storage area.

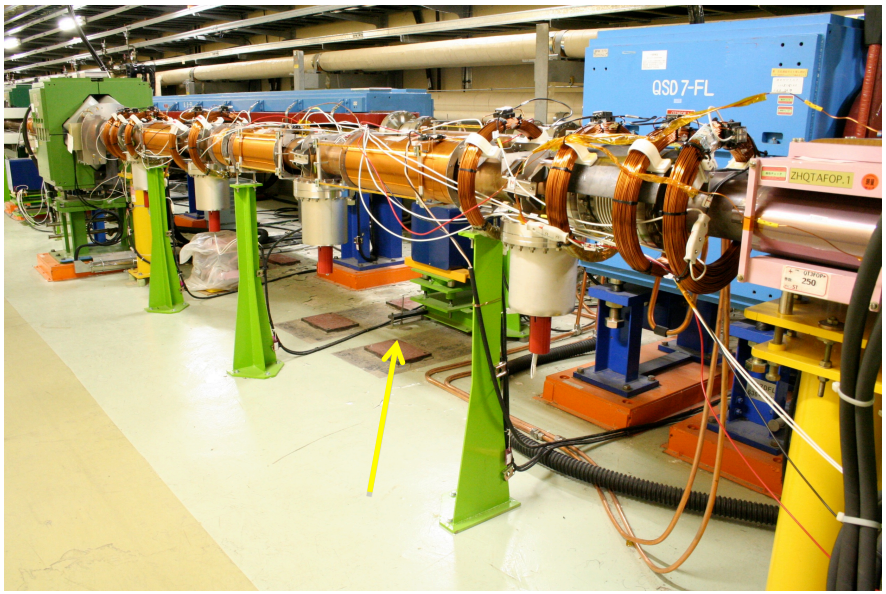
Magnet type	# of Mag. removed from KEKB so far	Mag Weight (t)	Net Weight (t)	comments
LER B	107	~3	~320	~30 magnets will be reused at SuperKEKB. Looking for someone who can use them.
Steering	860	~0.4	~340	~60% of them will be reused with some modification. Looking for someone who can use them.
Wiggler	134	~3	~400	~20 still remains in the tunnel. All wigglers will be reused at SuperKEKB.
			>1000	Vacuum pipes (& the solenoid coils) are not included.

4. Survey & Alignment Status

- Main ring
  - Strengthened geodetic network
- IR
  - Analyzed floor motion during the Belle roll-out.
  - Strategy for cryostat alignment

Monument survey





When the KEKB magnets were first installed in the TRISTAN tunnel in 1997, there was no sophisticated geodetic network to be used.

There were only floor monuments, which indicate the central positions of the removed TRISTAN quadruple magnets,
every ~8 m.

Now some are covered by the KEKB magnets, cables, supports…

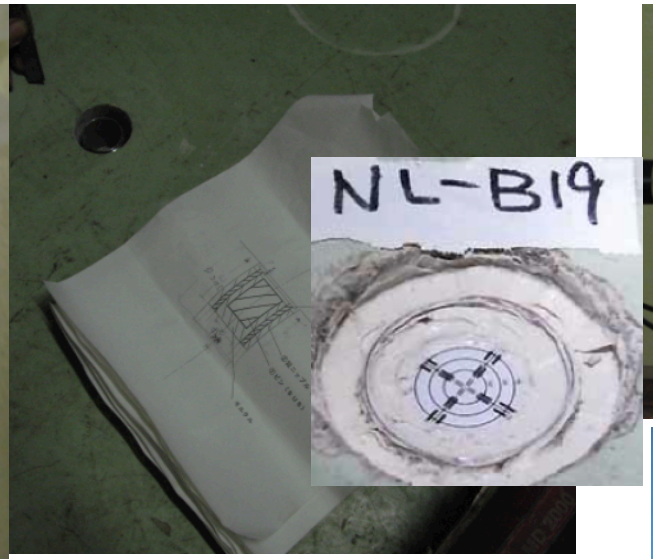
We need more monuments which we can see.

➔Need for new geodetic network

Added more monuments and surveyed them along with the KEKB magnets.

We need to understand the present positions of the KEKB magnets as most of the magnets in the arc sections will remain in the beam line.

Newly added monuments installed on the wall, floor and so on

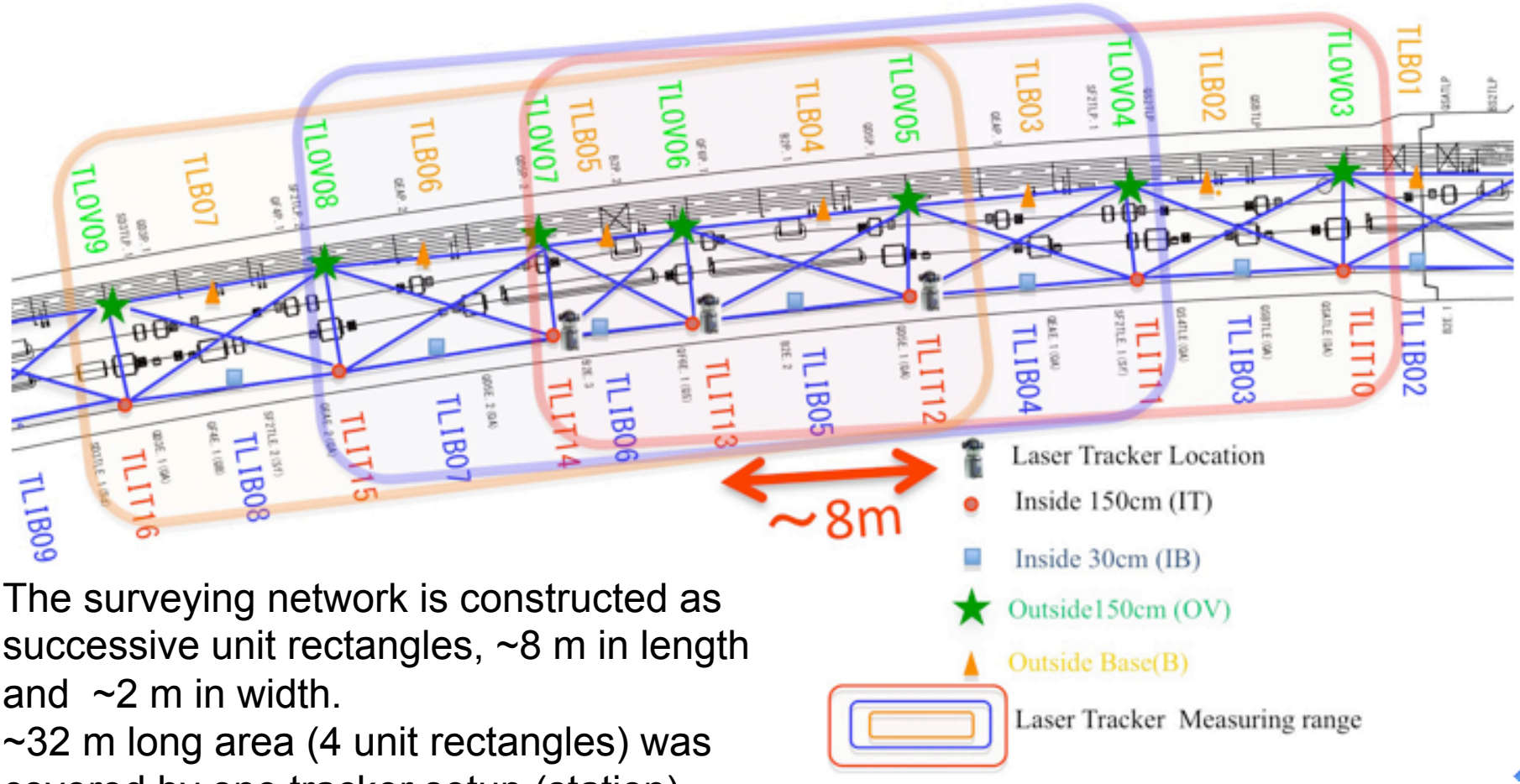


Very difficult to find space for stable monuments.

Our tunnel is ~3 decade old.
Experienced two generation accelerators,
TRISTAN (single ring)
and KEKB (double ring, more crowded).

Lots of junk (cables, pipes,,,) not much space especially on the cable rack side.

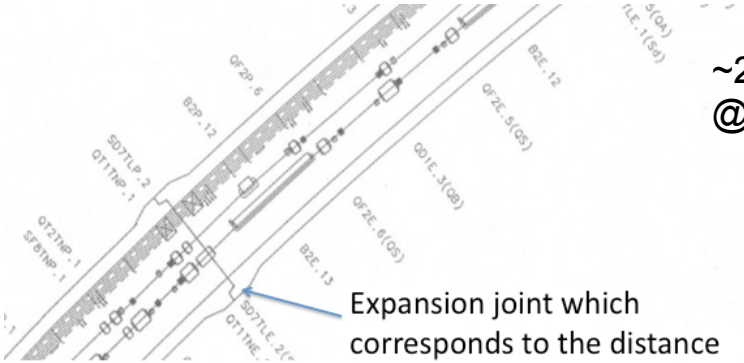
New geodetic network

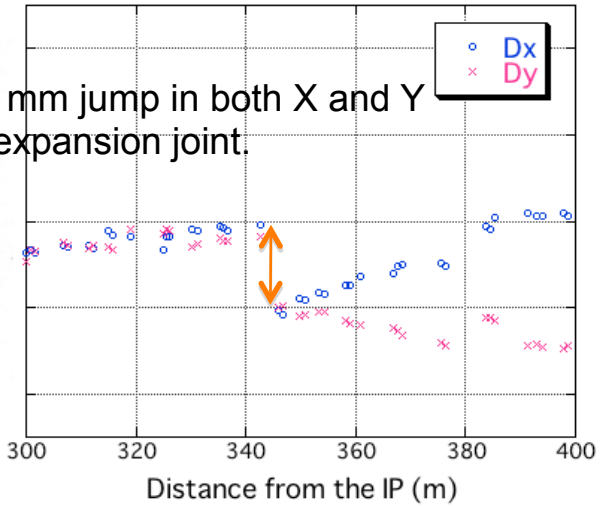


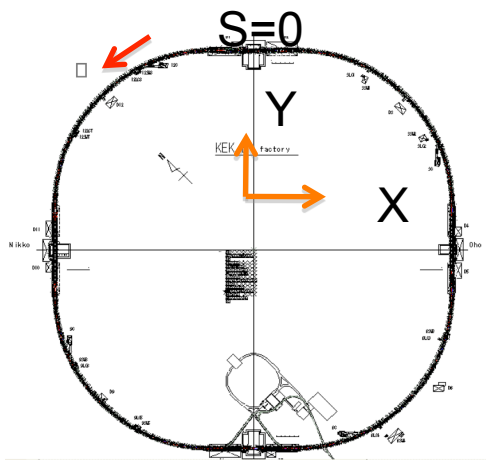
The surveying network is constructed as successive unit rectangles, ~8 m in length and ~2 m in width.
~32 m long area (4 unit rectangles) was covered by one tracker setup (station).

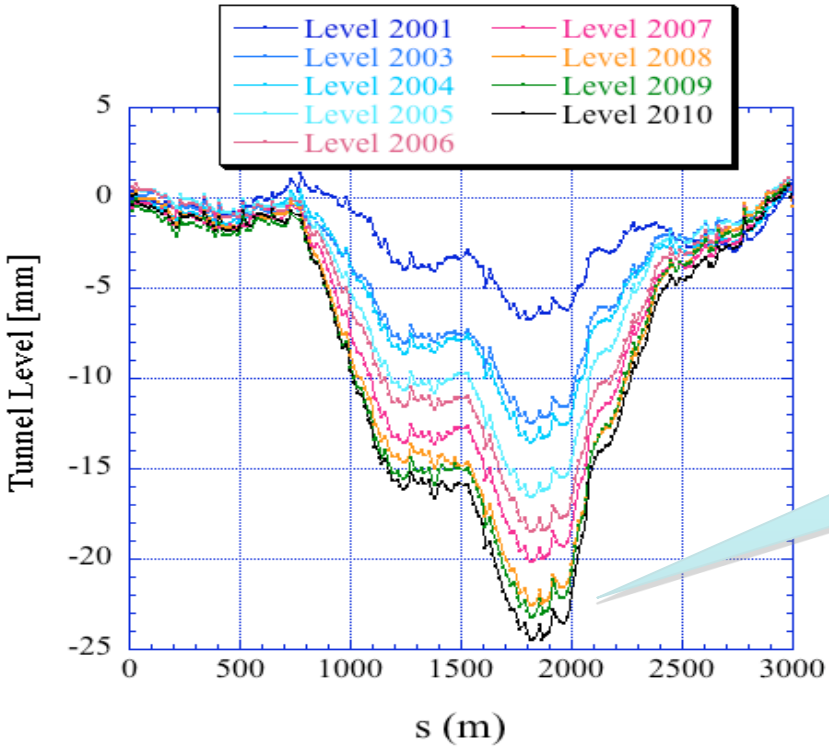
Survey results, next

Tunnel is deformed horizontally & vertically







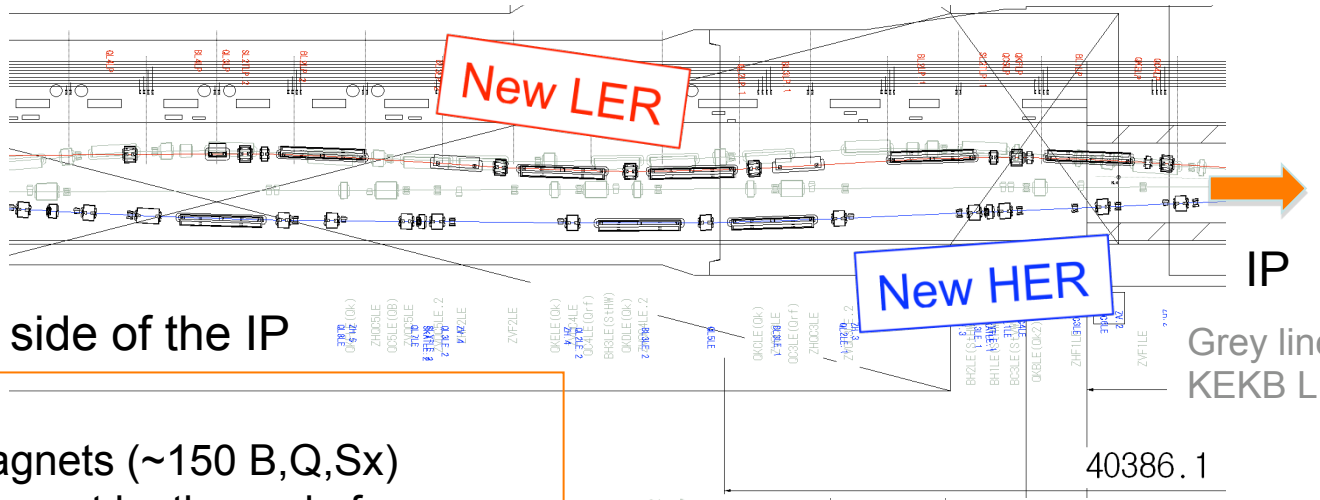


South arc continues to sink
at an average rate of ~2 mm/year,
though the rate seems to vary year to year.
The reason why this particular part
of the tunnel sinks is not known.

Optics people say
Overall leveling is not needed.
Just smoothing out locally.

New look of the Tsukuba straight section

Lattice not finalized yet



Left side of the IP

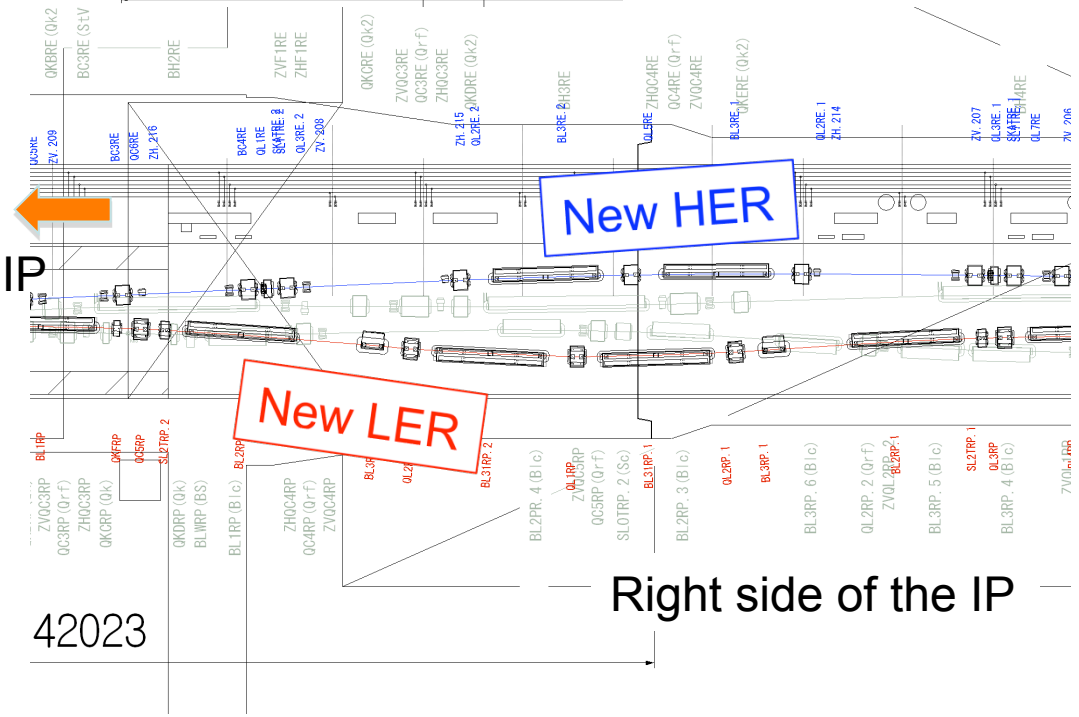
Grey lines :
KEKB LER/HER beam lines

Plan:
All the magnets (~150 B,Q,Sx)
to be taken out by the end of summer,
followed by the power cable removal.

Tunnel floor repair.

Survey for defining the new LER/HER
magnet positions in the summer.

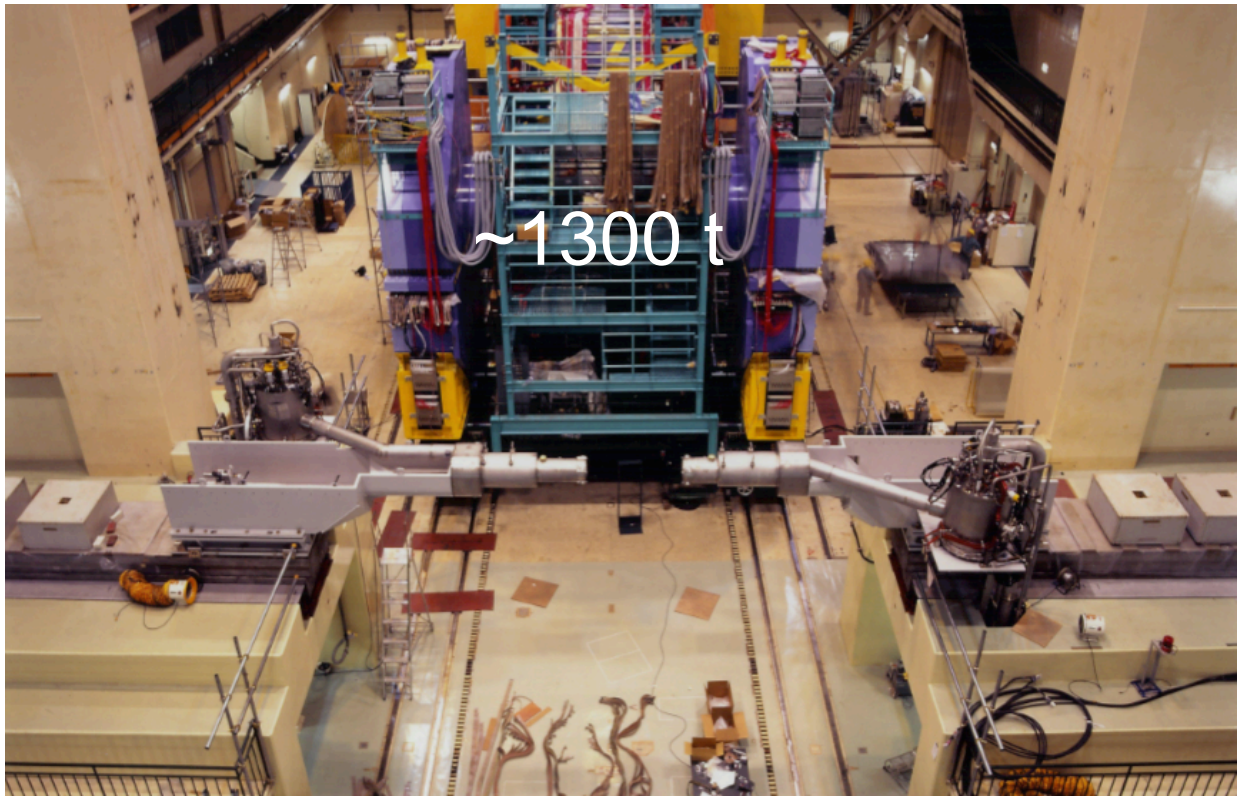
Baseplate installation.



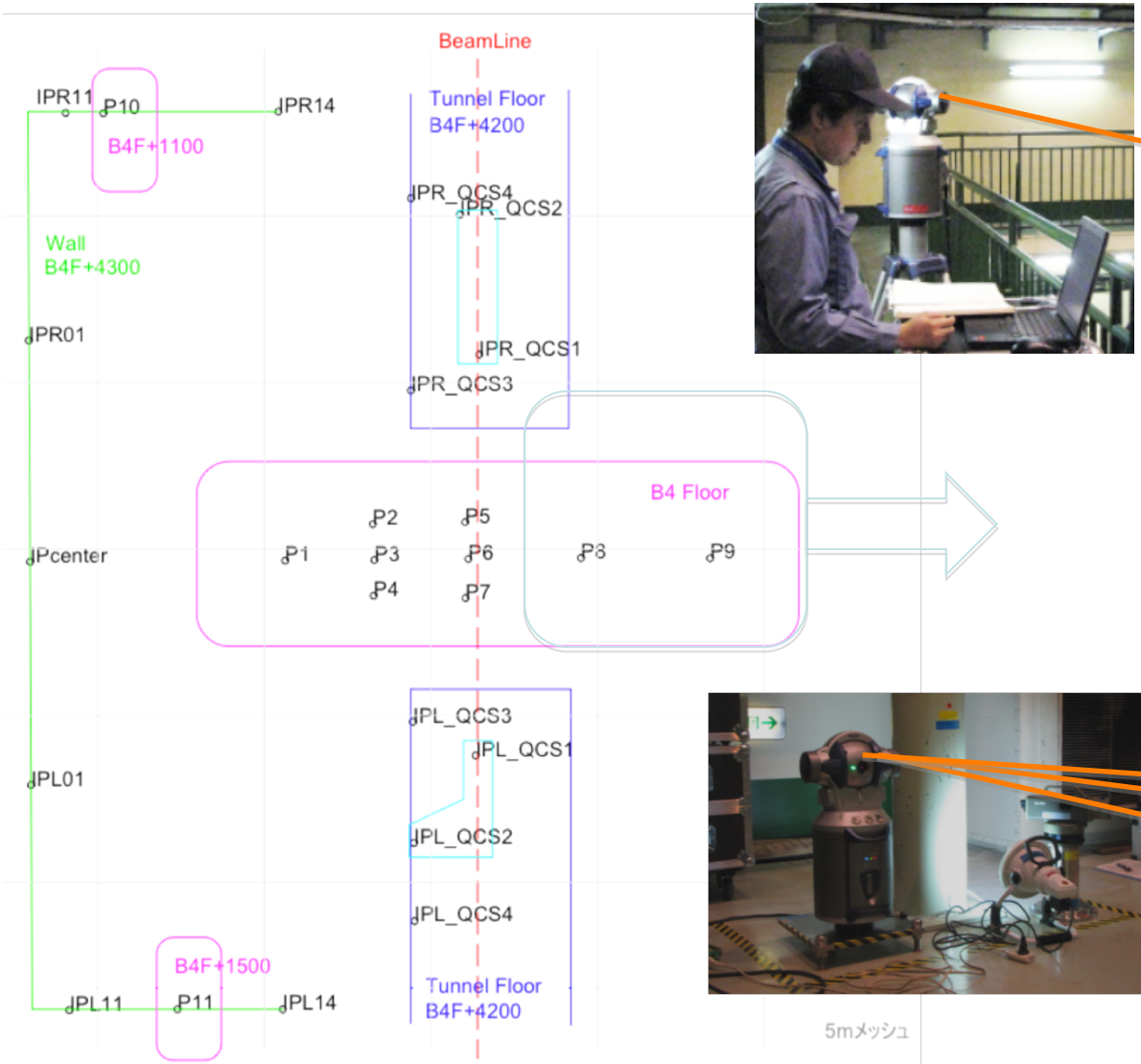
Right side of the IP

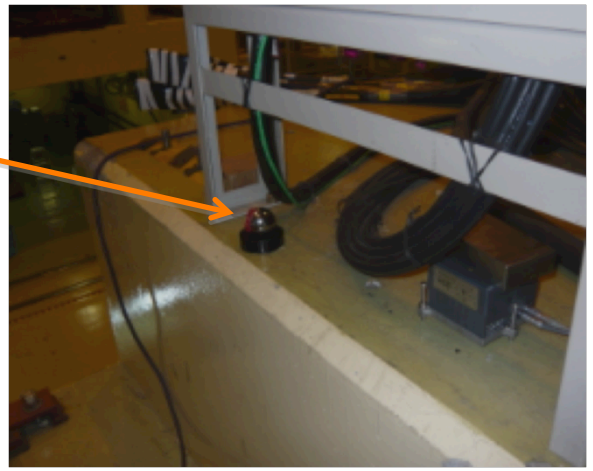
Beam line & floor motion during Belle roll-out analyzed.

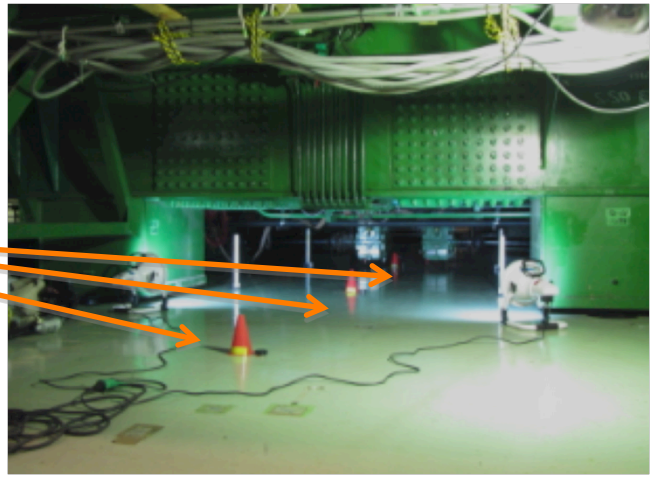
This should be taken into account when evaluating the alignment tolerances (or/and the specs for QC correction coils) for SuperKEKB QC's along with the cryostat motion due to the electro-magnetic force when Belle solenoid/QCs are being ramped up.



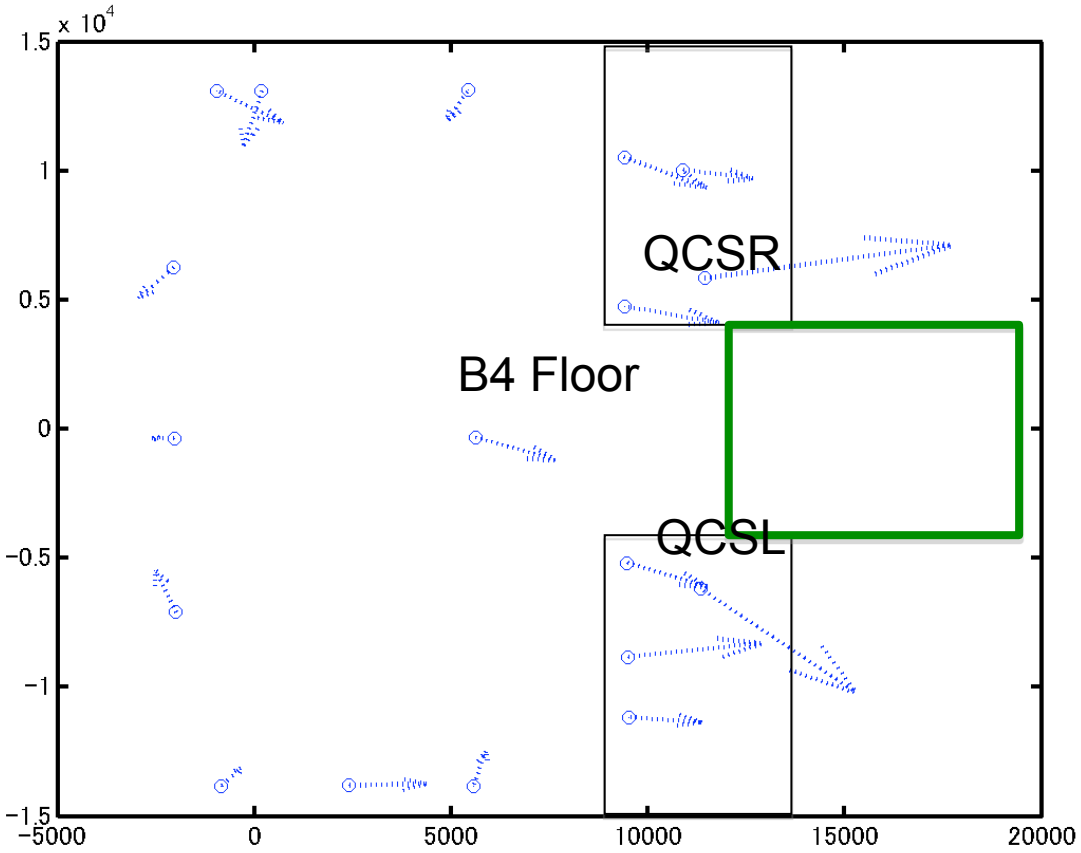
Beam line floor & Cryostat (retracted) motion





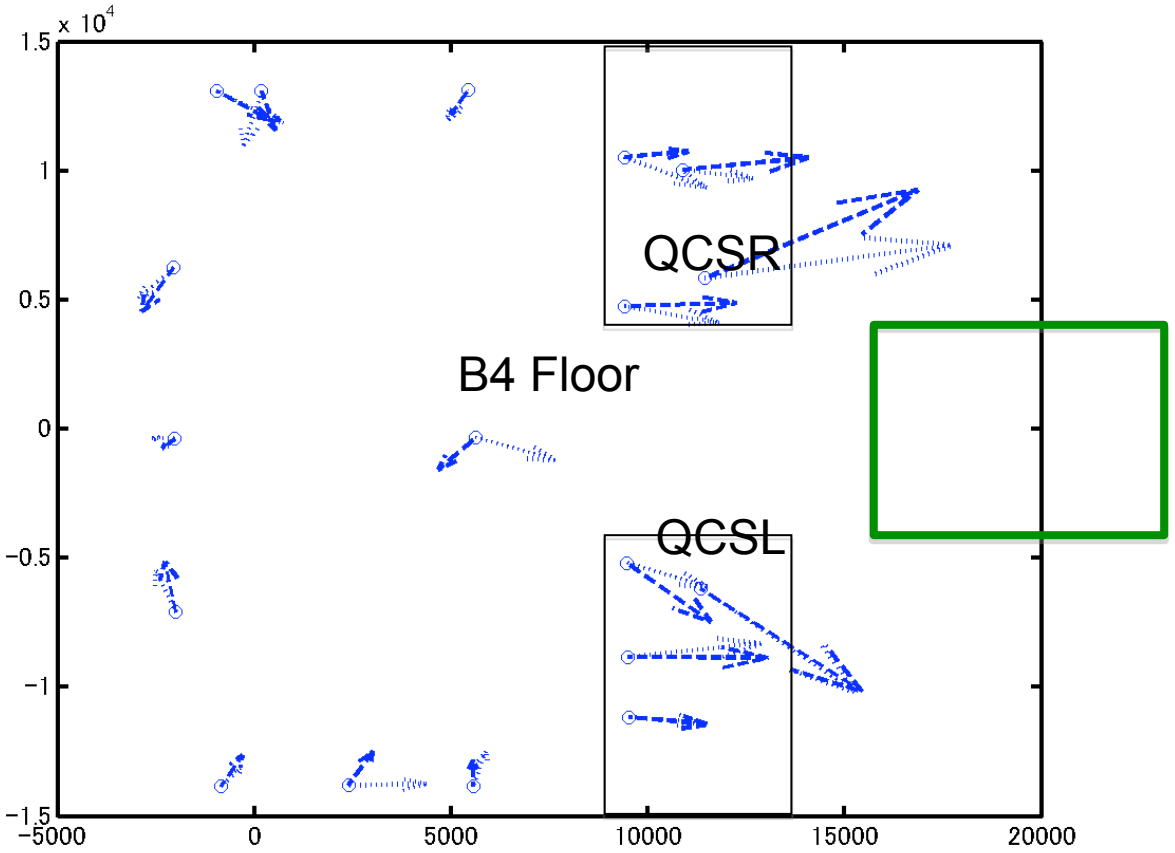


Horizontal motion of the B4 floor & beam line floor & Cryostat (retracted)



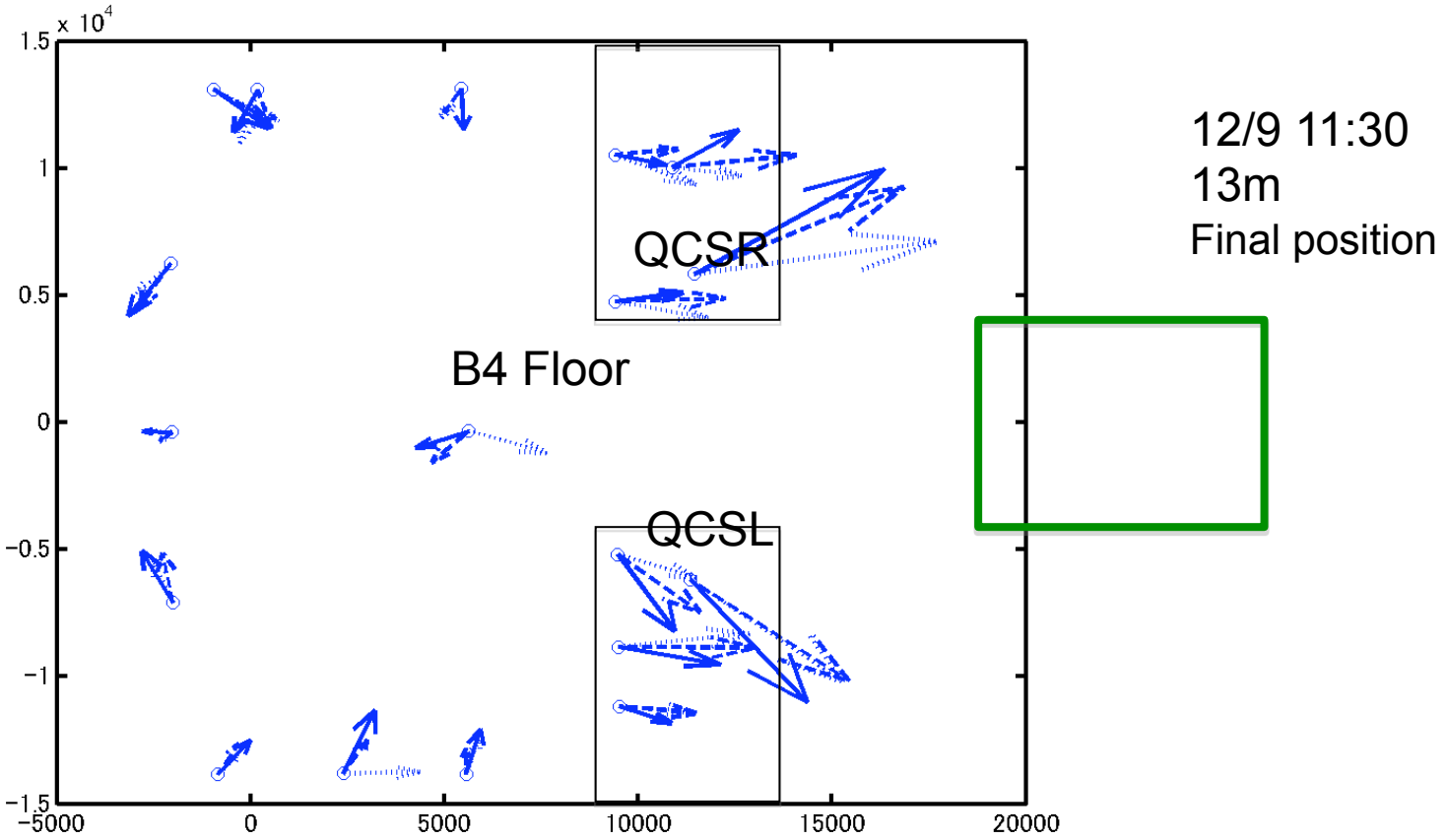
12/9 10:00
5m

Horizontal motion of the B4 floor & beam line floor & Cryostat (retracted)

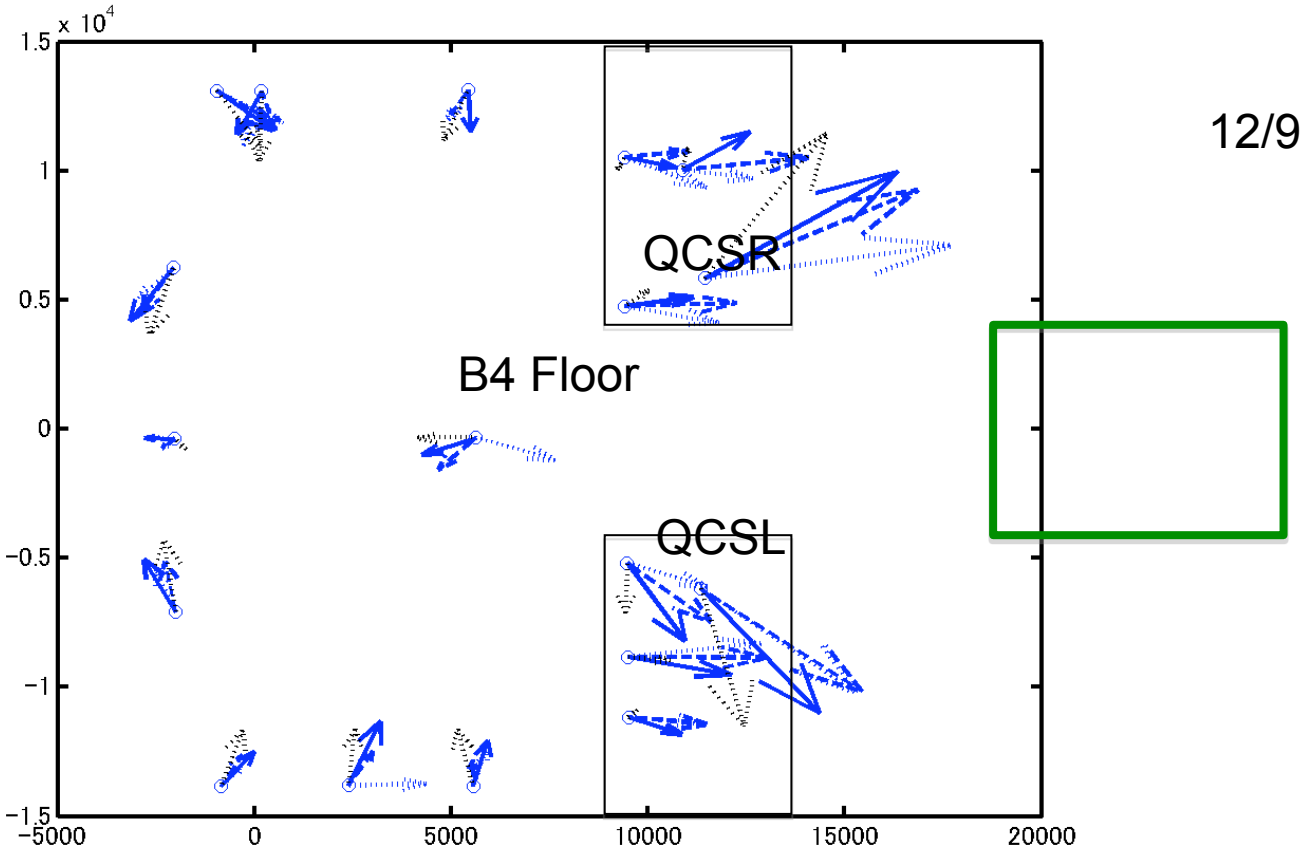


12/9 11:00
10m

Horizontal motion of the B4 floor & beam line floor & Cryostat (retracted)

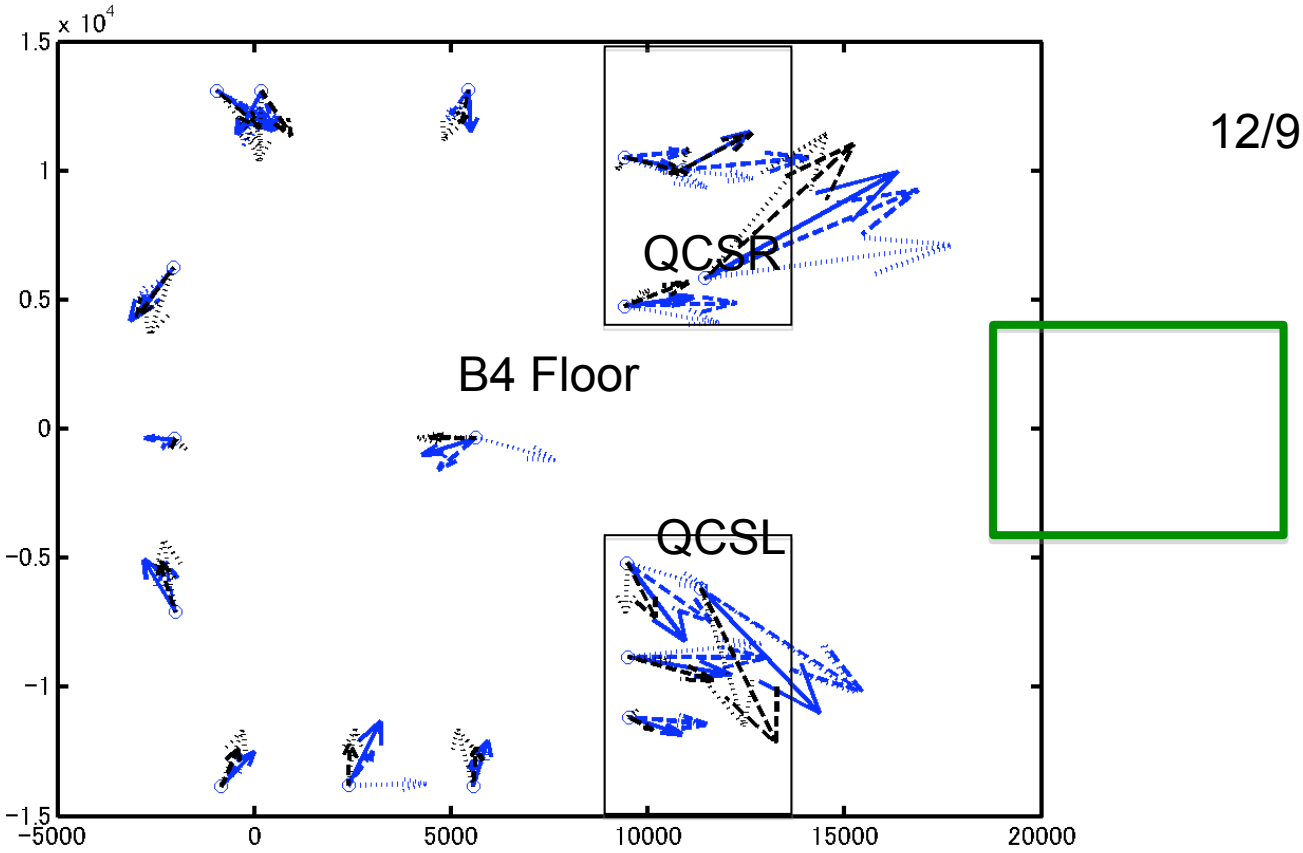


Horizontal motion of the B4 floor & beam line floor & Cryostat (retracted)



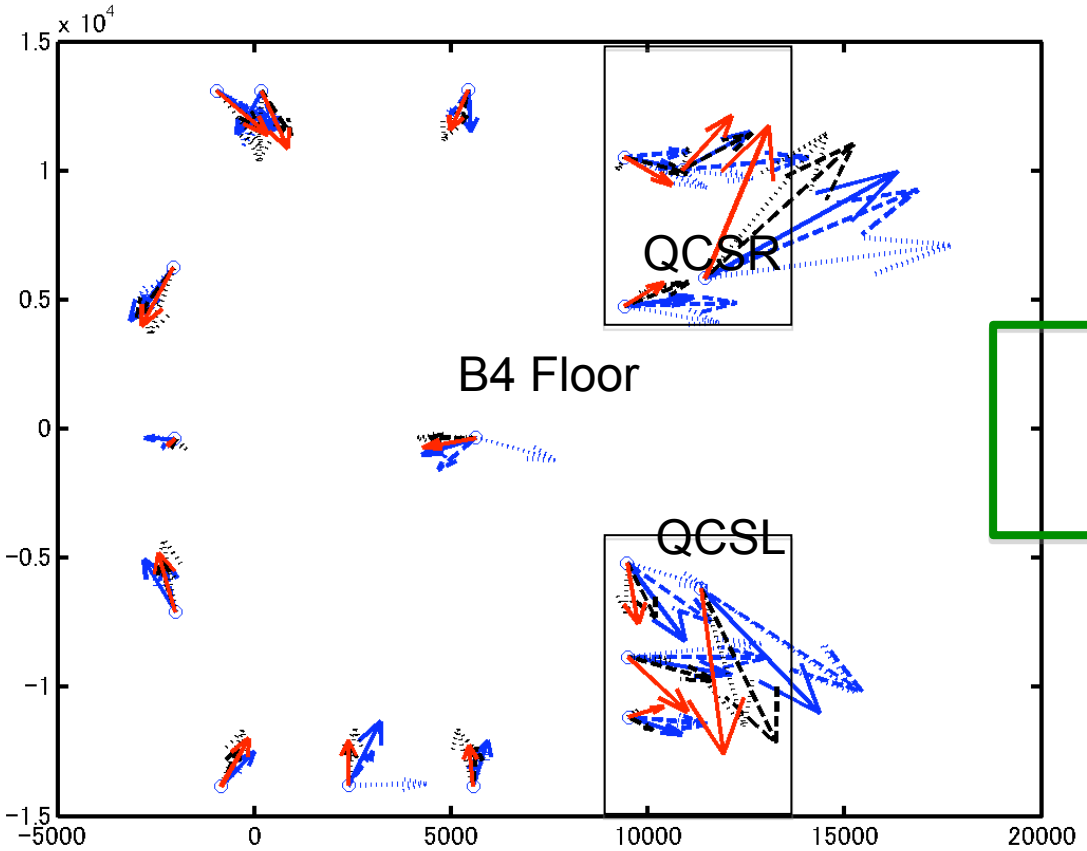
12/9 14:00

Horizontal motion of the B4 floor & beam line floor & Cryostat (retracted)



12/9 17:00

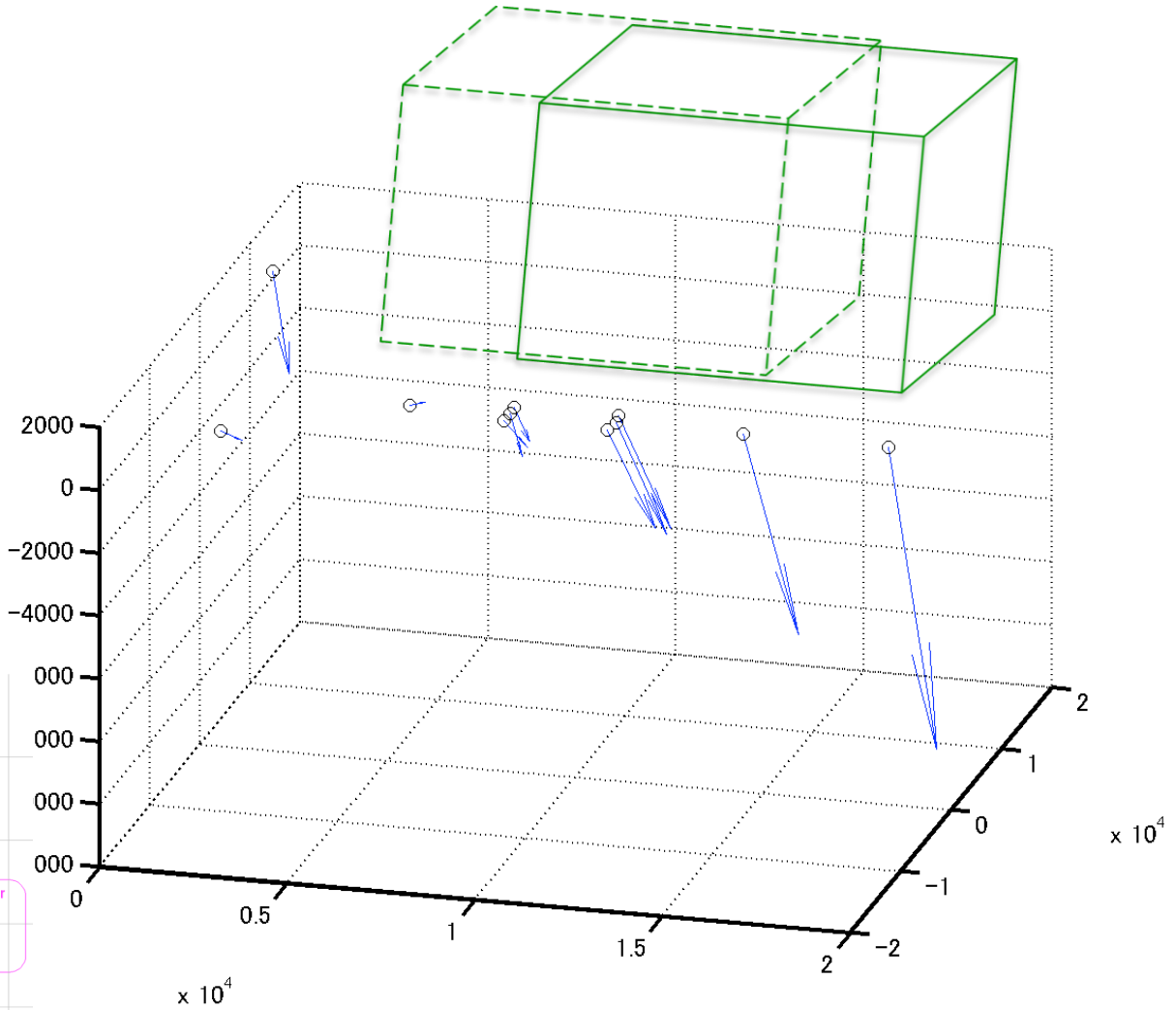
Horizontal motion of the B4 floor & beam line floor & Cryostat (retracted)

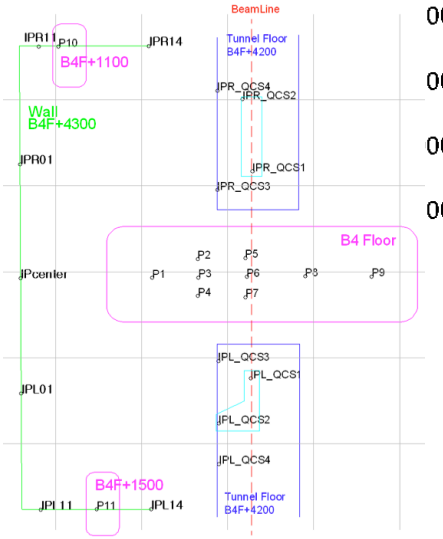


12/10 9:00

Belle pulls the beam line with it.

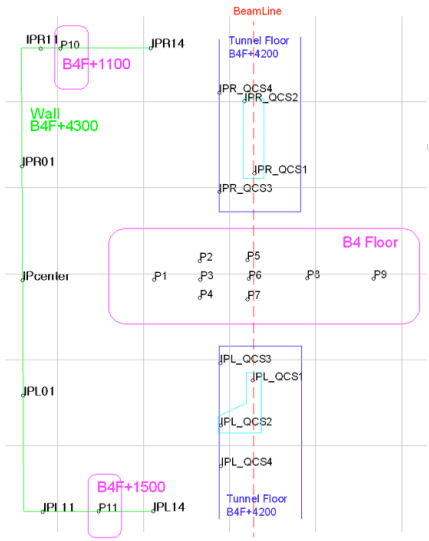
Vertical motion of the B4 floor

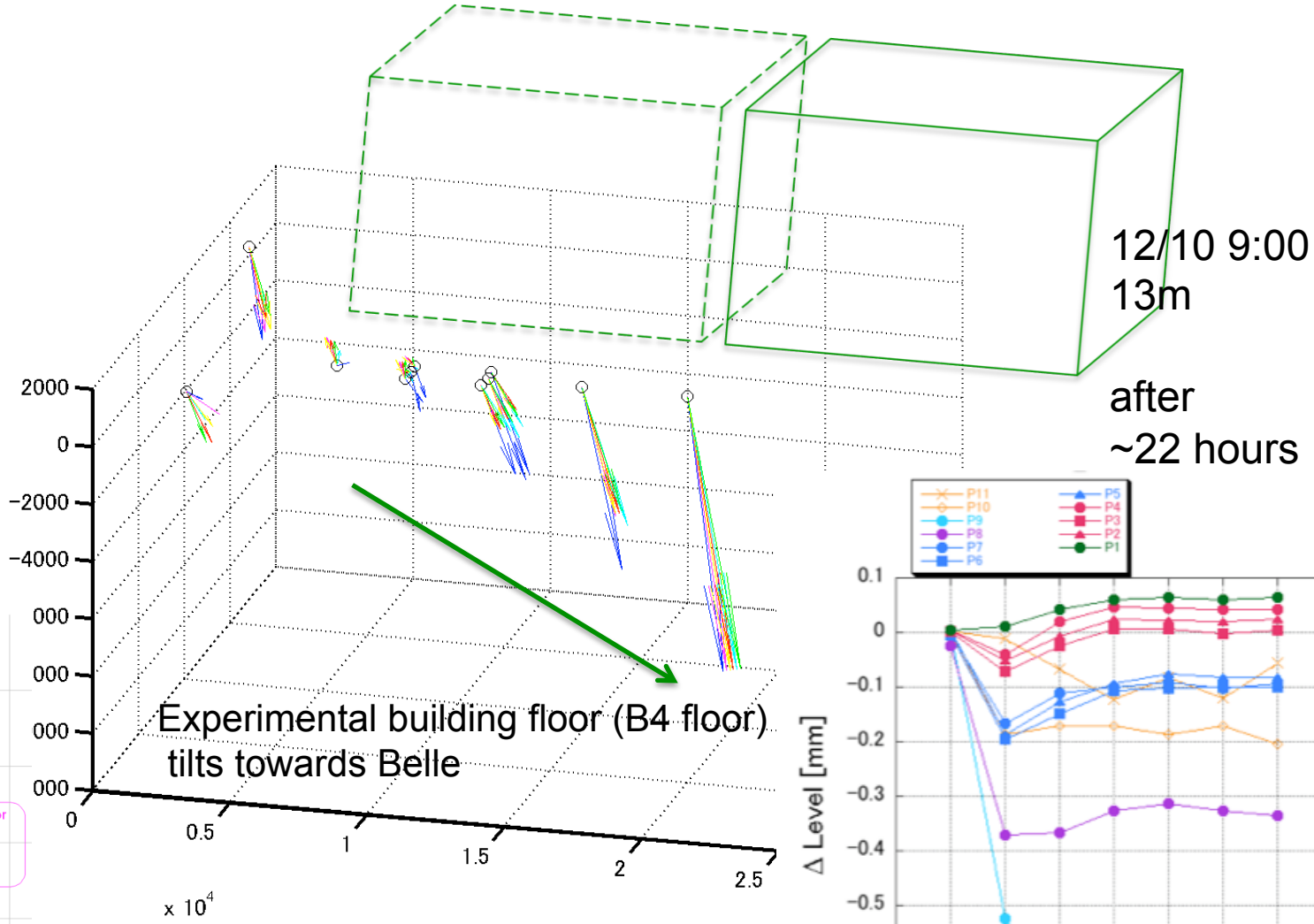




12/9 10:00
5m

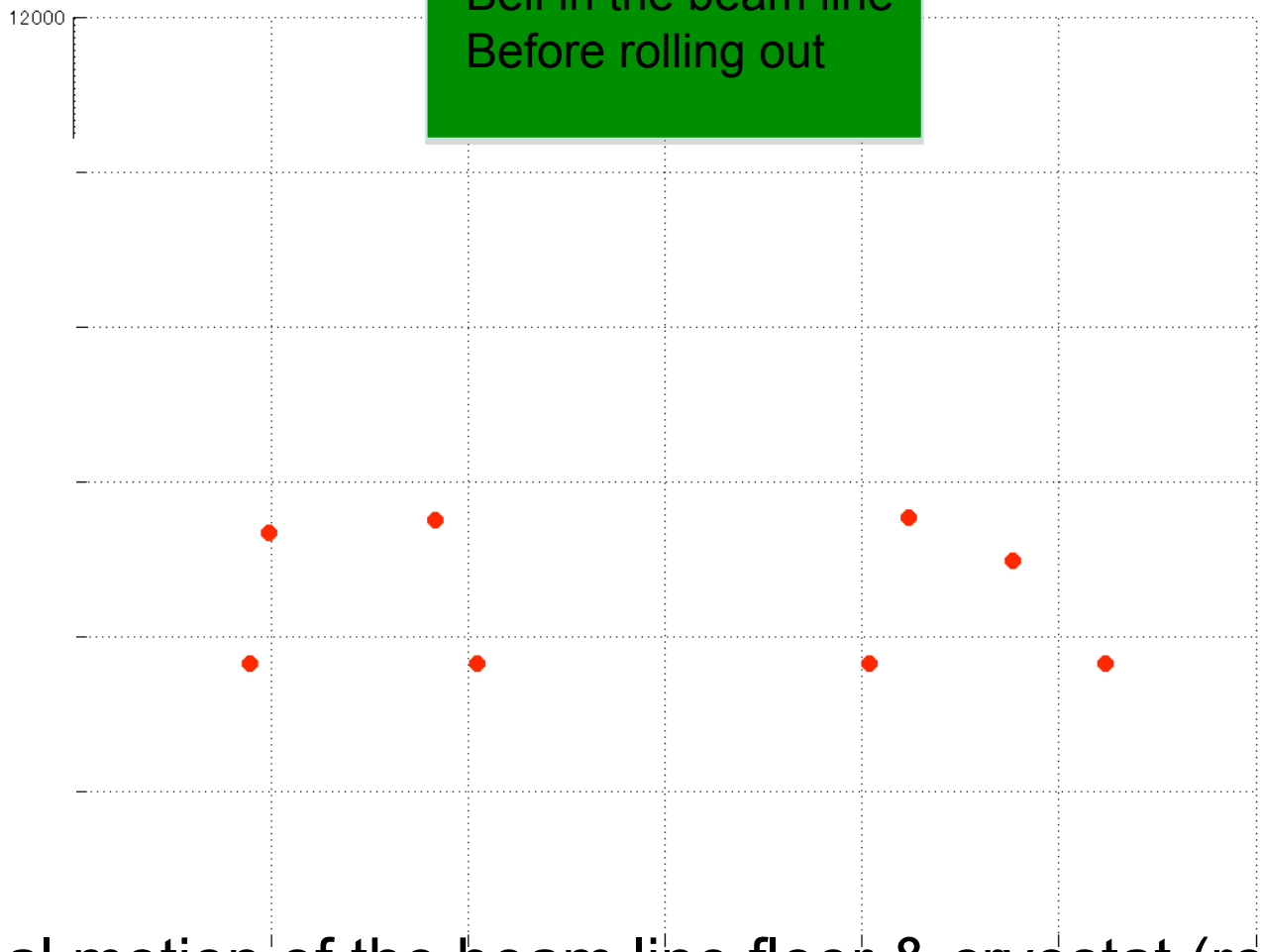
Vertical motion of the B4 floor



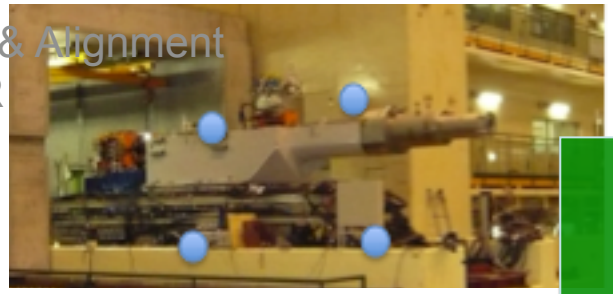


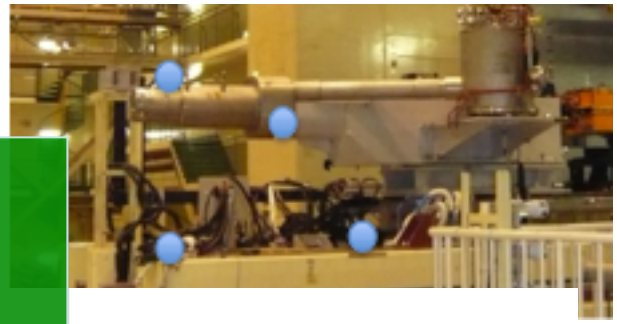
4. Survey &
Status : IR

Bell in the beam line
Before rolling out

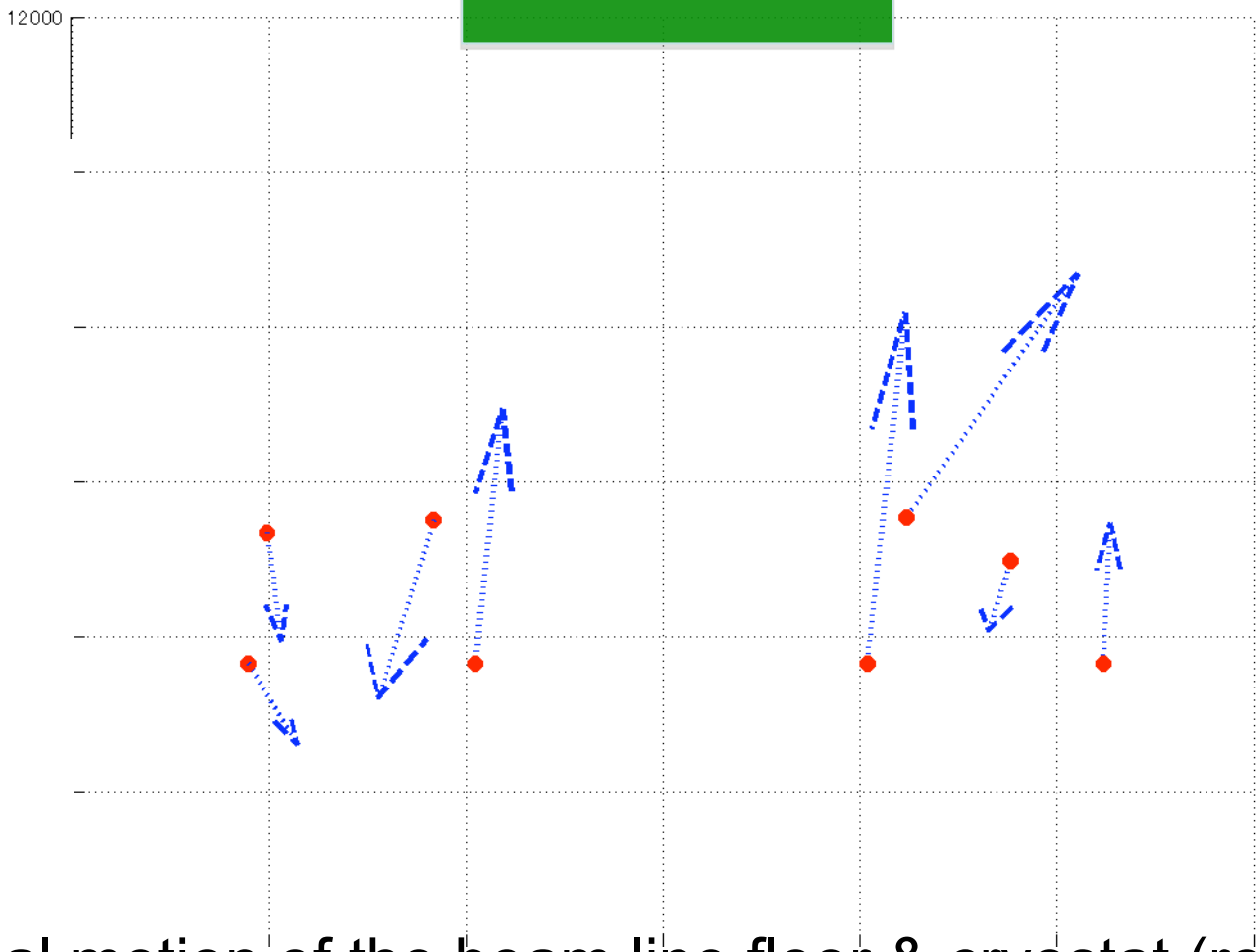


Vertical motion of the beam line floor & cryostat (retracted)

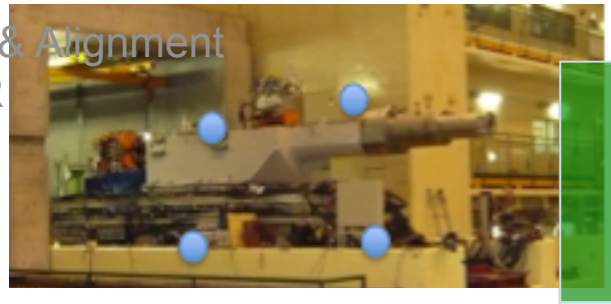




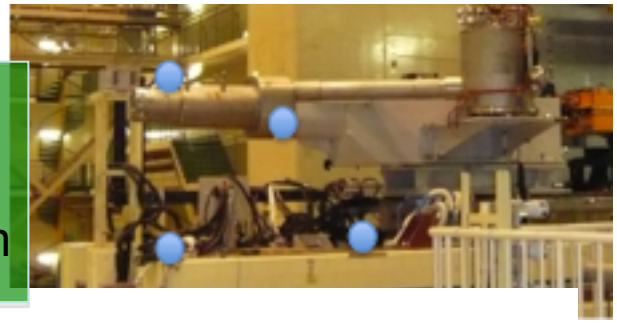
Dec. 9th 10:00
Rolled out 5m

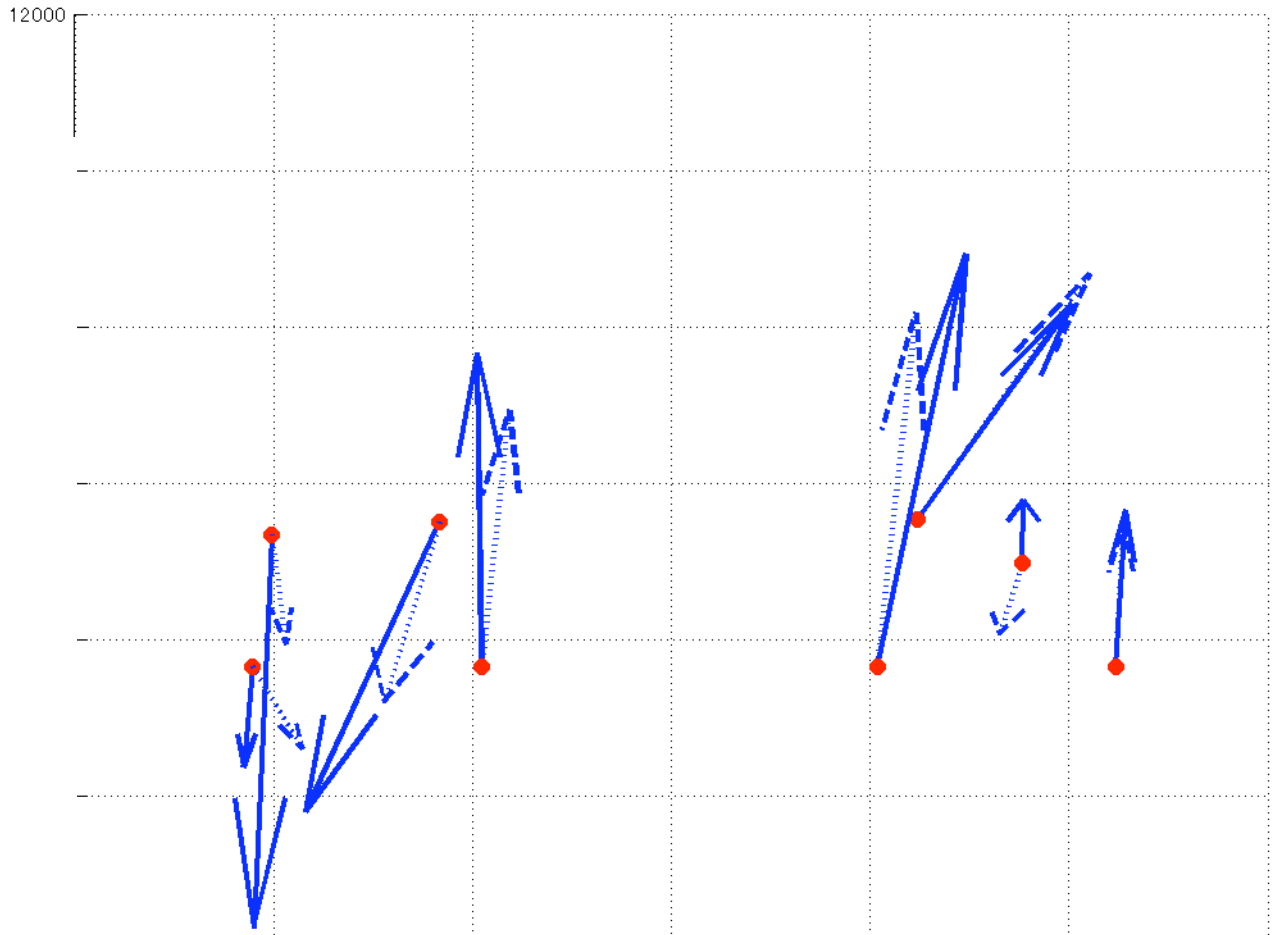


Vertical motion of the beam line floor & cryostat (retracted)

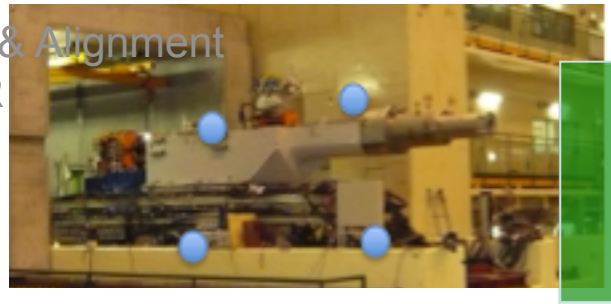


Dec. 9th 11:00
Rolled out 10m

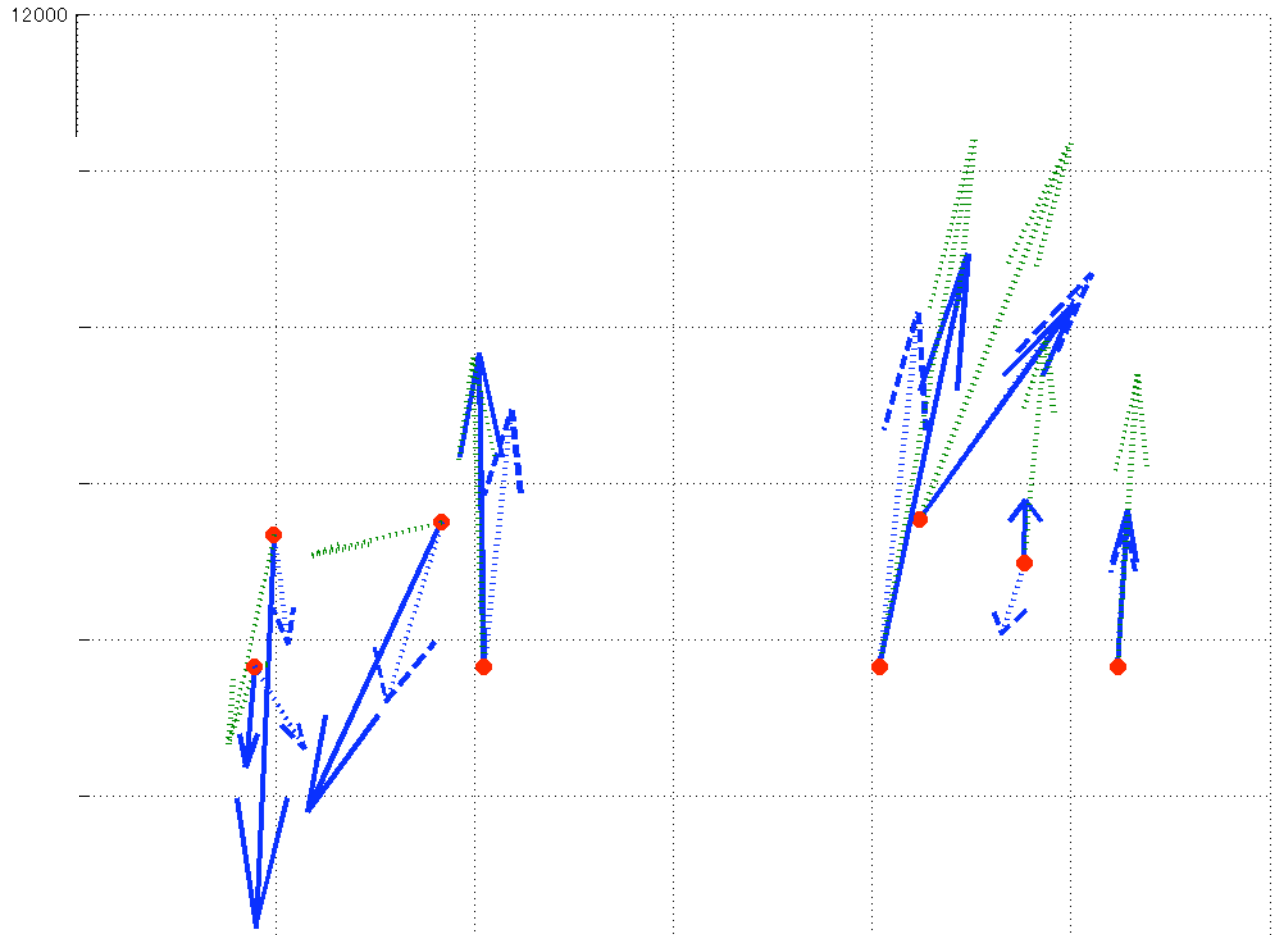




Vertical motion of the beam line floor & cryostat (retracted)

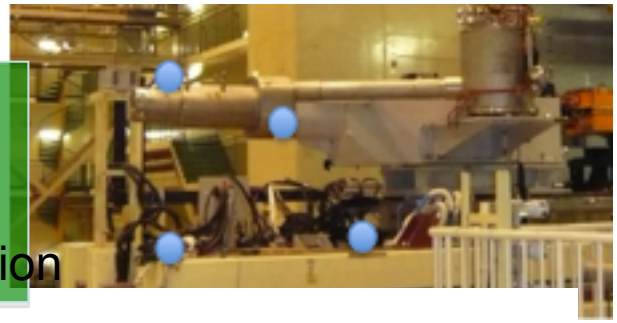


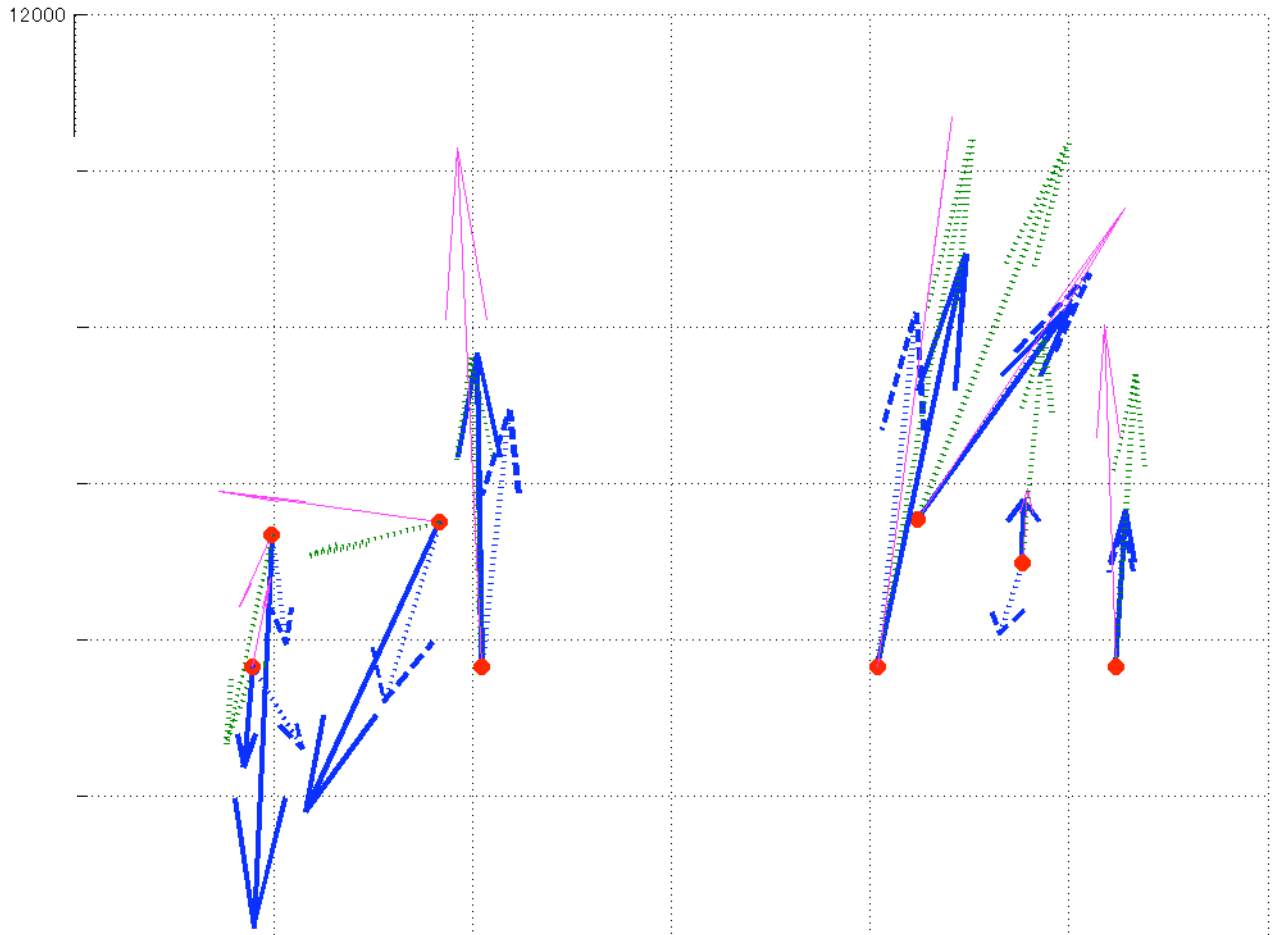
Dec. 9th 11:30
Rolled out 13m
Final position



Vertical motion of the beam line floor & cryostat (retracted)

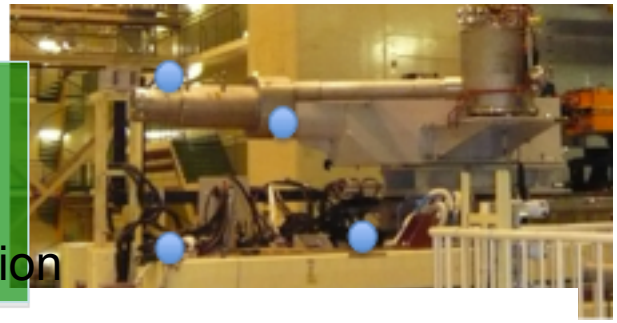
Dec. 9th 14:00
3 hours from
Roll-out completion

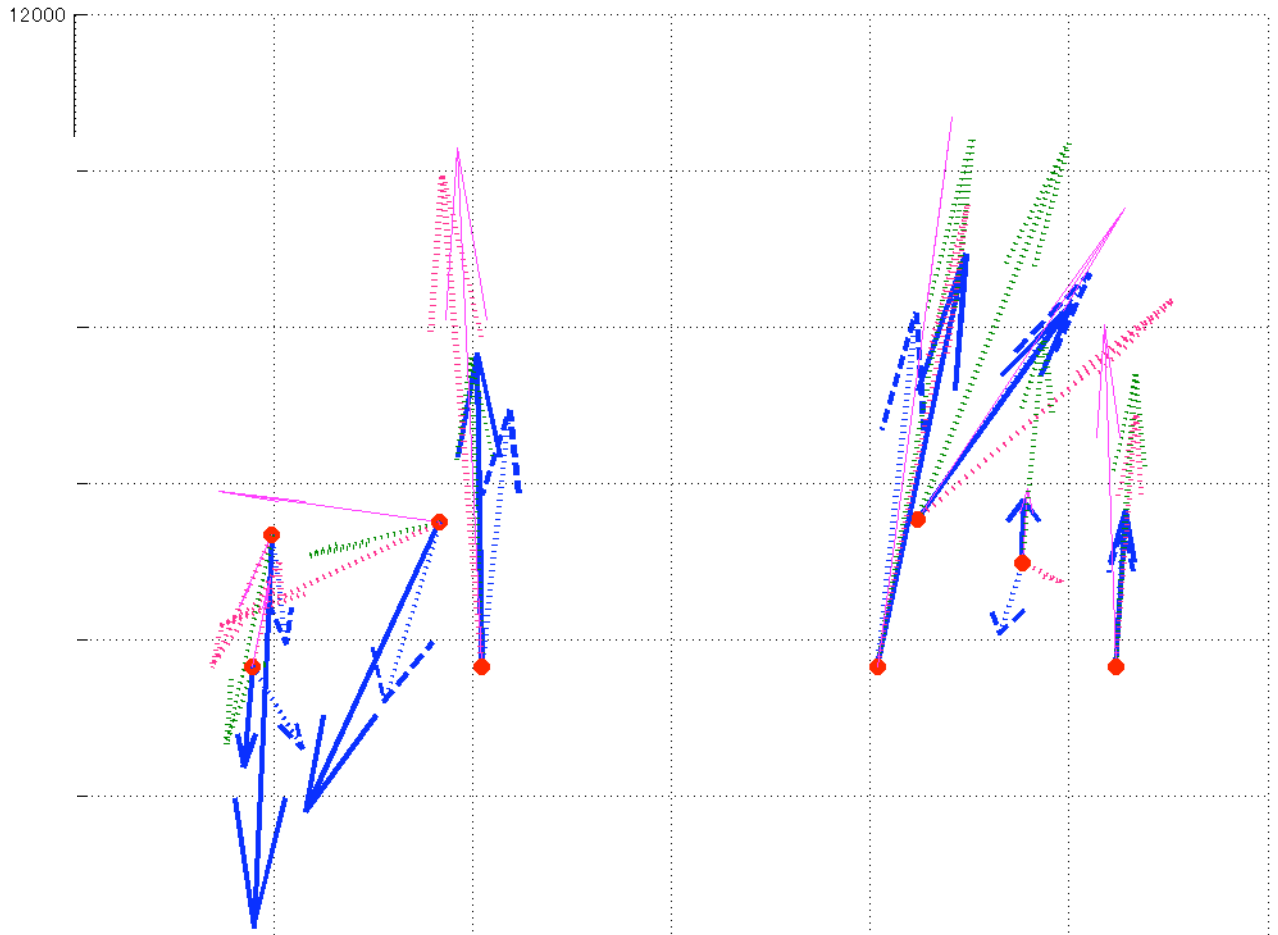




Vertical motion of the beam line floor & cryostat (retracted)

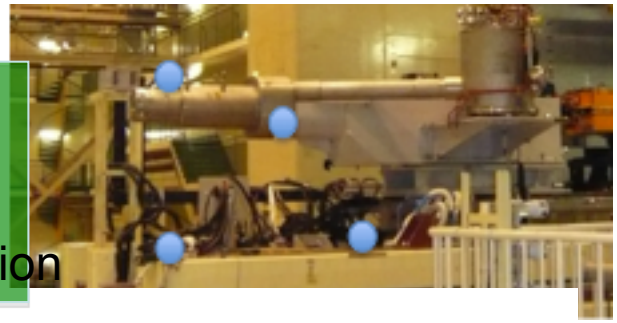
Dec. 9th 17:00
6 hours from
Roll-out completion

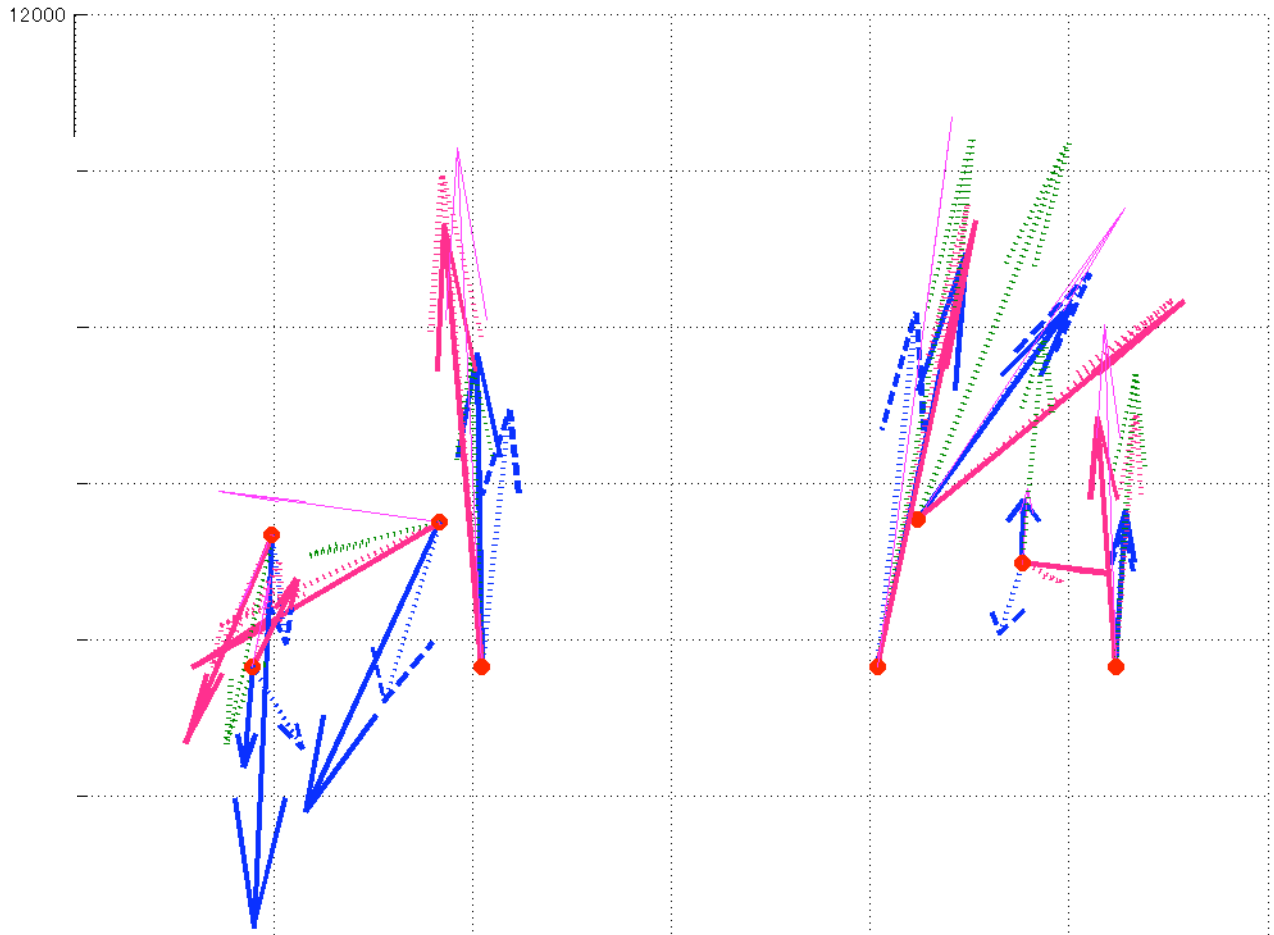




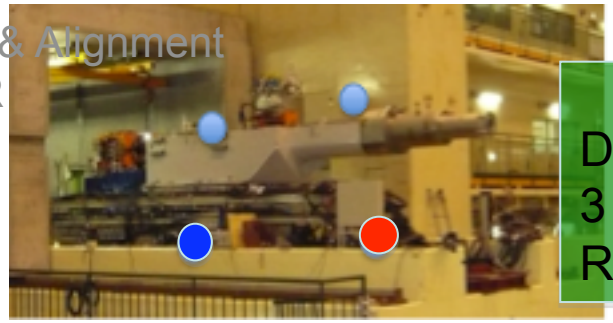
Vertical motion of the beam line floor & cryostat (retracted)

Dec. 10th 9:00
22 hours from
Roll-out completion

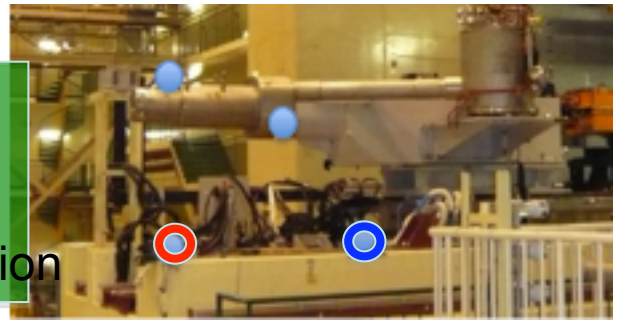


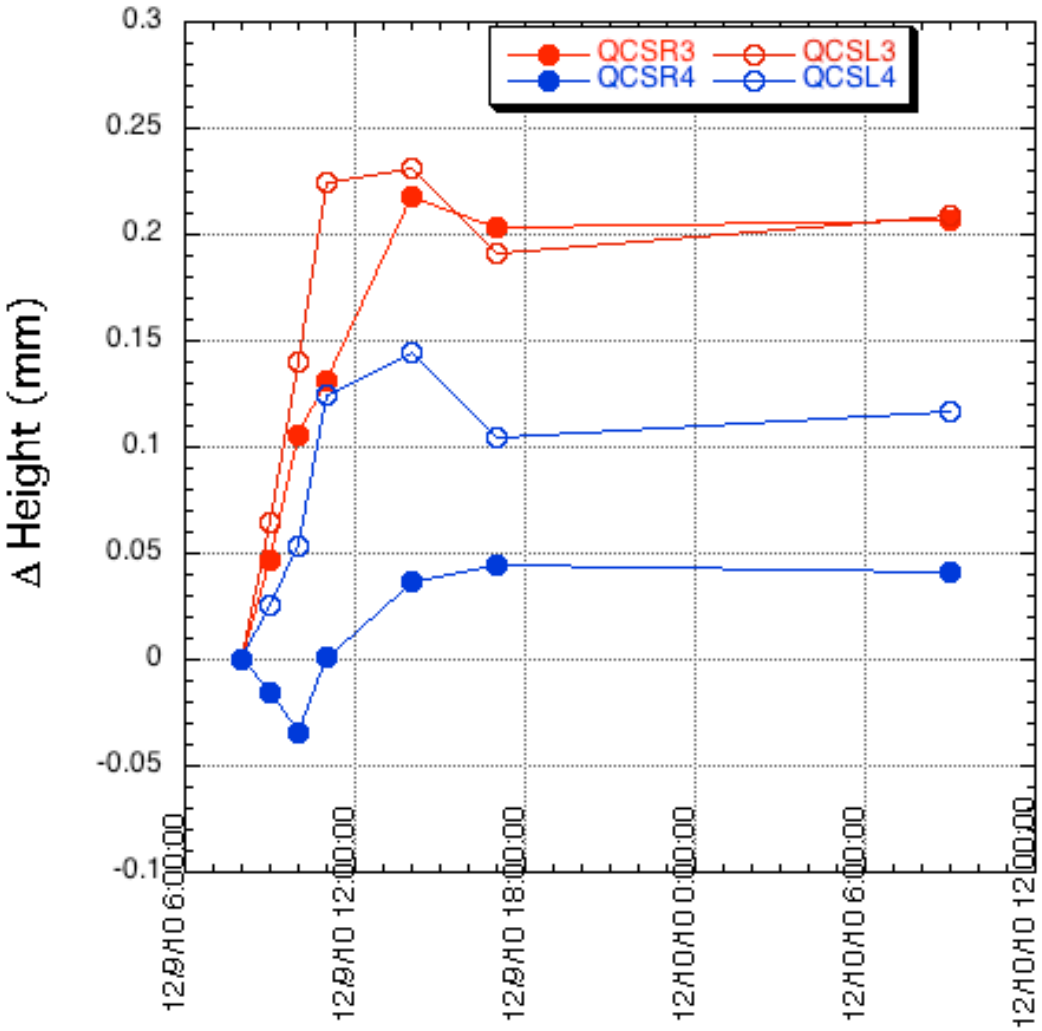


Vertical motion of the beam line floor & cryostat (retracted)

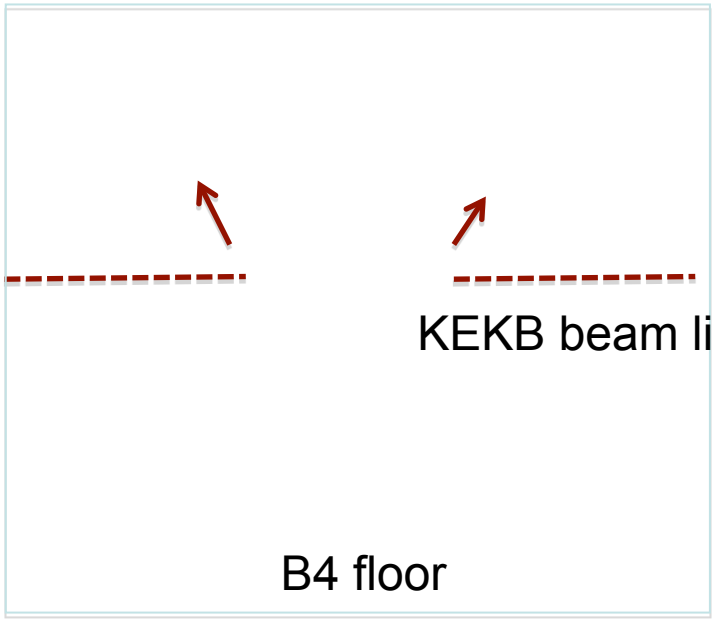


Dec. 9th 14:00
3 hours from
Roll-out completion





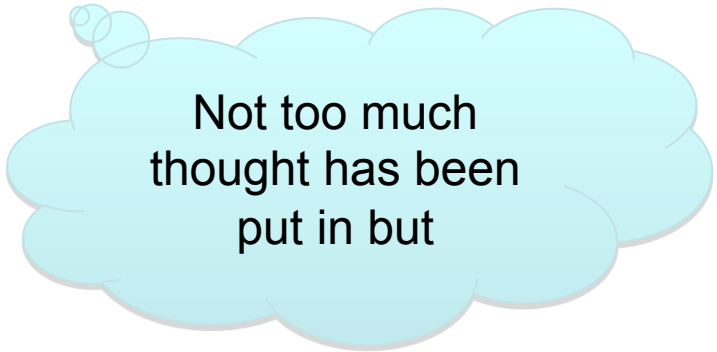
Tsukuba experimental hall



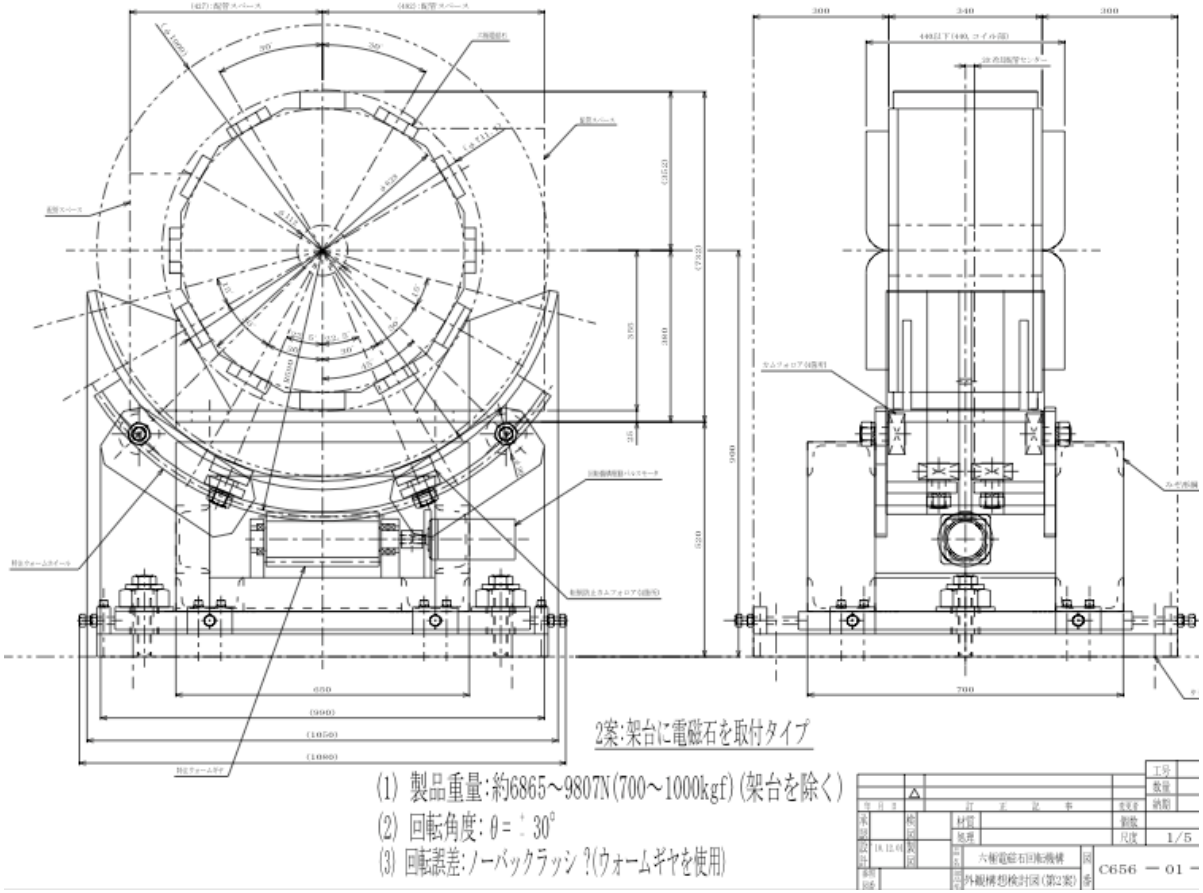
KEKB beam line opens up like
a drawbridge when Belle moves away.

5. Other issues

- Skew quad windings on Sextupole magnets
- Rotating sextupole magnets (physically) by as much as ±30 degree
- IR movable table design
- …



Rotation of normal conducting sextupole magnets (700kg and up)



Challenges:
Range ±30 degree
Good reproducibility
Small backlash

Rotate with heavy cables?
Rotate with cooling pipes?

Mechanically stable

R&D is scheduled from April.

6. Summary

- KEKB tunnel dismantling
  - Almost done except for Tsukuba straight section, a part of Oho wiggler section and the Fuji test beam line.
- Magnet design & fabrication on-going.
  - LER dipoles, wigglers, some quads, LER V-steering.
  - ~100 main magnets still need to be fabricated.
- Magnet measurement systems need to be prepared and tested.
  - We plan to evaluate all magnets at KEK except for V-steering.

- Survey network expanded.
  - Monuments increased.
  - Tunnel deformation observed (needs to be monitored during the construction?)
- Effects of Belle roll-out examined and will be fed back to the IR alignment strategy, QC cryostat fiducialization, QC correction coil specs…

- R&D on sextupole magnet rotation will start soon.
- And of course, the power supply systems ➔Next speaker.

I need another member（教官、技官）in my group.

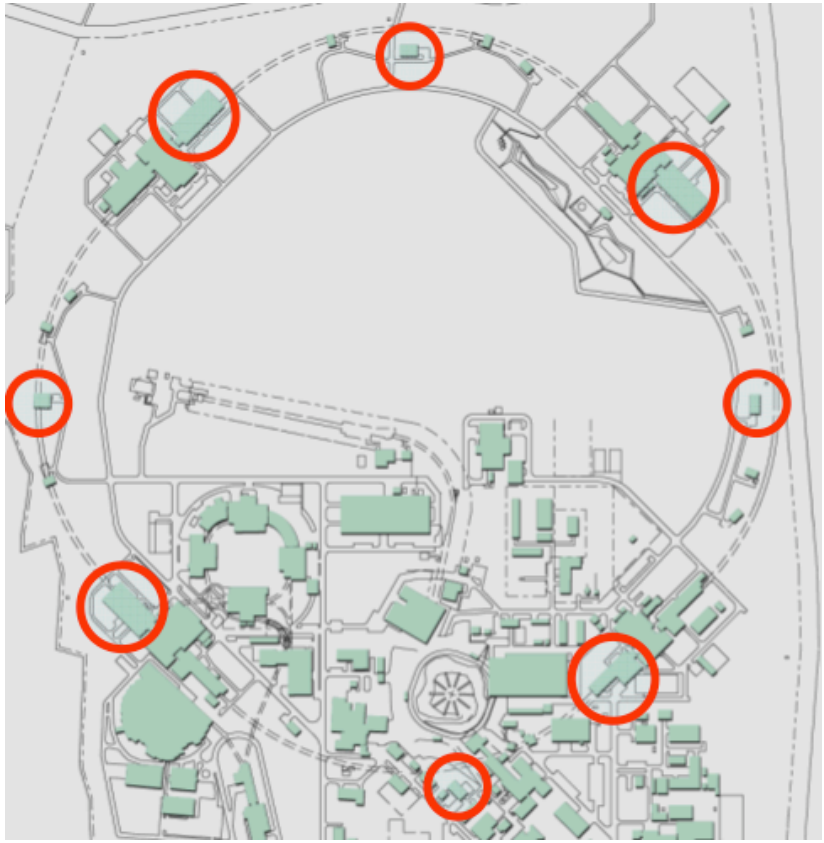
Upgrade plan for Magnet Power Supply System

T. Kawamoto
T. Sueno
N. Tokuda
T. Oki

Contents

- Power supply buildings
- Cables
- Power supplies (existing / to be developed)
- Typical data (stability / ripple)
- R&D

Power supply buildings

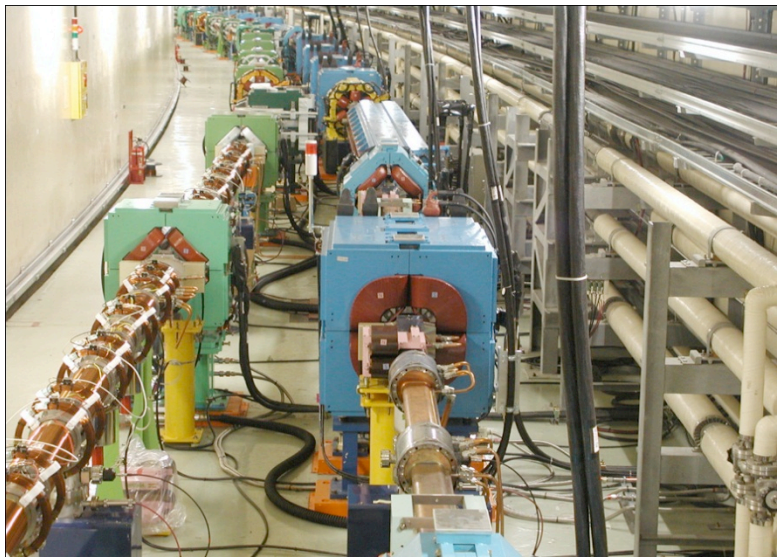


8 power supply buildings.
More than 2300 power supplies exist for KEKB.
The PS buildings are already very crowded.
We requested additional space & power receiving and distribution facilities.

Cables

from power supplies
follow thru a pit…

and hole…



via rack,

then connected to
magnets.

into KEKB tunnel

How much of the cable we can recycle is not clear.
(Can we pull out the cable at bottom of everything else ?)
In order to replace the cables, identification of each cable is necessary,
before cutting, pull out, extend and joint cables.

Existing Power supplies

We have ~ 2300 power supplies:

Class	# of power supplies	Typical load
Small class (< 10 A, 0.5 kW)	1885	Steering magnet etc
Medium class (< 500 A, 100 kW)	368	Local Quads
Large class (< 500 A, 500 kW)	14	Quad families
Very old MW class (< 1250 A, 1 MW)	6	Bending and Wigglers

Typical spec.

Stability	< 20 ppm / day
Ripple	< 10 ppm
Setting error	< ± 50 ppm (16-bit DAC)

Existing Power supplies

We have ~ 2300 power supplies:

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Medium class (< 500 A, 100 kW)	368	Local Quads
Large class (< 500 A, 500 kW)	14	Quad families
Very old MW class (< 1250 A, 1 MW)	6	Bending and Wigglers

Small and Medium class power supplies will be reused for SuperKEKB after appropriate maintenance and overhaul.

-10 years old / frequently broken parts should be replaced.
- Switching module is out of manufacture,
  and compatible module may be use after modification.

New Power supplies to be developed

Except for the PS for Bending and Wigglers, the spec. has not been fixed.

Power	# of power supplies	Typical load
0.95 MW (860 A)	2	B (HER / LER)
< 0.98 MW (1400 A)	8 (+ 8)	Wigglers (LER) (HER?)
< 500 kW (500 A)	(~ 14)	Q families (HER / LER)
< 100 kW (500 A)	(~ 50)	Local Q (HER / LER)
~ 10 kW (1000 A)	(~ 10)	QCS main
~ 0.5 kW (± 50 A)	(~ 50)	QCS correction
(Max. 540 kW	many	Damping Ring)

Target spec. for B and Wigg.

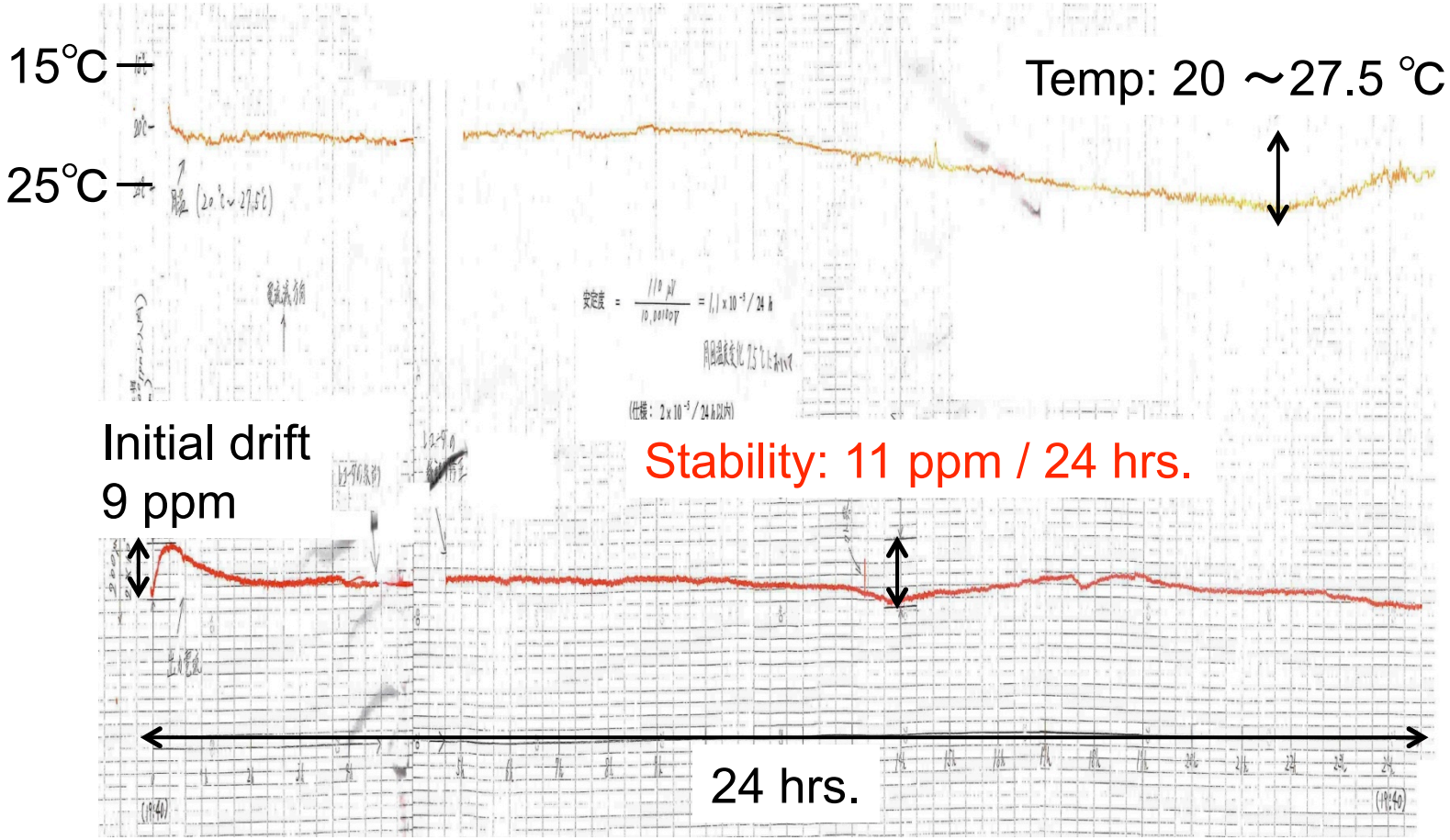
Stability	< 2 ppm / day
Ripple	< 1 ppm
Setting error	< ± 0.1 ppm (~23-bit)

Typical long-term stability

Prototype power supply for QCS main coil

Power supply: Transistor-dropper type (1000 A-30 V).

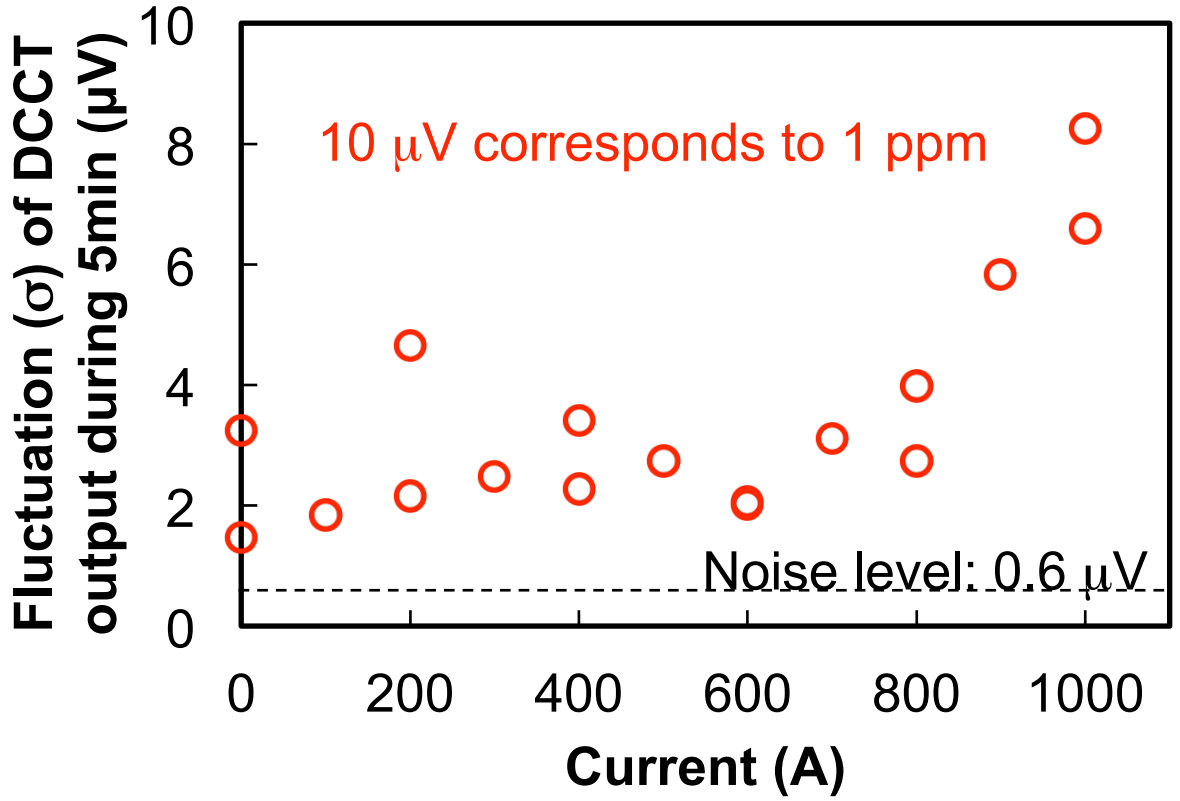
Test Load: 1.2 mΩ resistor



How much jitter on the measured current

For precious control, lower jitter is necessary on the current monitoring.
Current is measured by a DCCT and a DMM.

Power supply: Transistor-dropper type (1000 A-30 V).
DCCT: 1000 A / 10 V output
DMM: KEITHLEY 2002 (10 PLC, 20 V range)



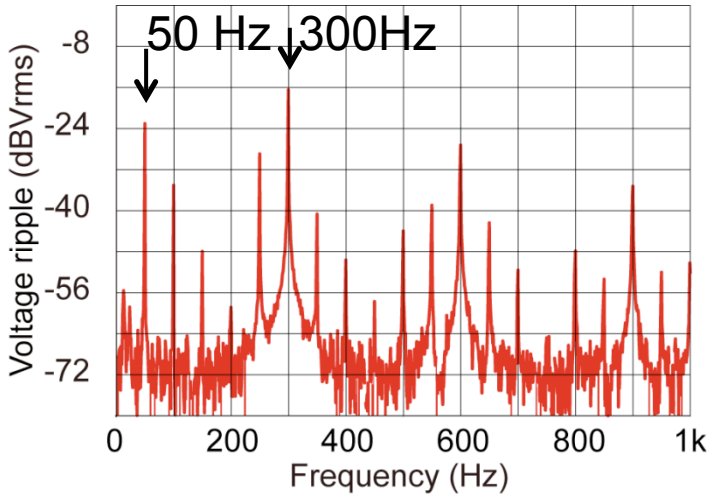
Typical ripple

QF4E magnet system

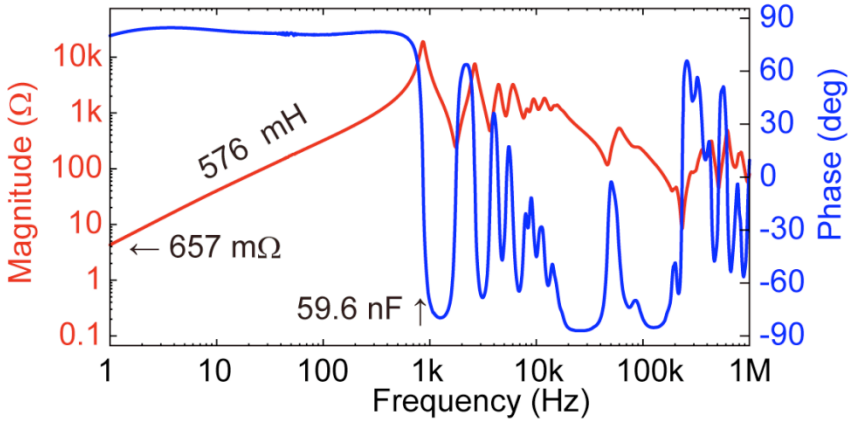
Power supply: Transistor-dropper type (500 A-380 V).

Load: 40 Quads connected in series around KEKB ring.

Measured voltage ripple



Measured load impedance



$Z \sim 0.66\ \Omega + 0.58\ H\ (f < 1kH)$

$$\text{Current ripple} = \frac{\text{Voltage ripple}}{\text{Load impedance}}$$

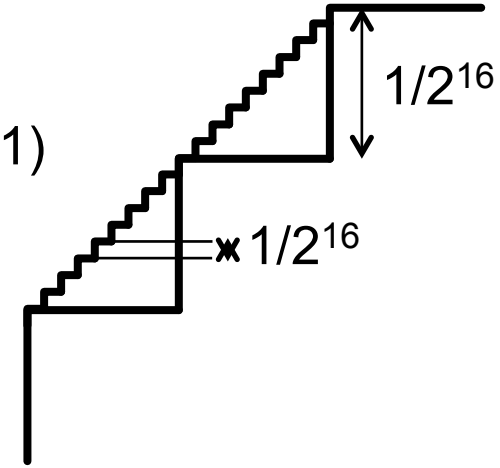
50 Hz: 0.7 ppm

300Hz: 0.3 ppm

R&D

For more precise setting / monitoring of the current,
increasing the DAC bits from present 16 to 20 or more is necessary.
Two methods are considerable.

1. Two 16-bit DAC's are combined.
2. Try new commercial use 20-bit DAC. (AD5791)

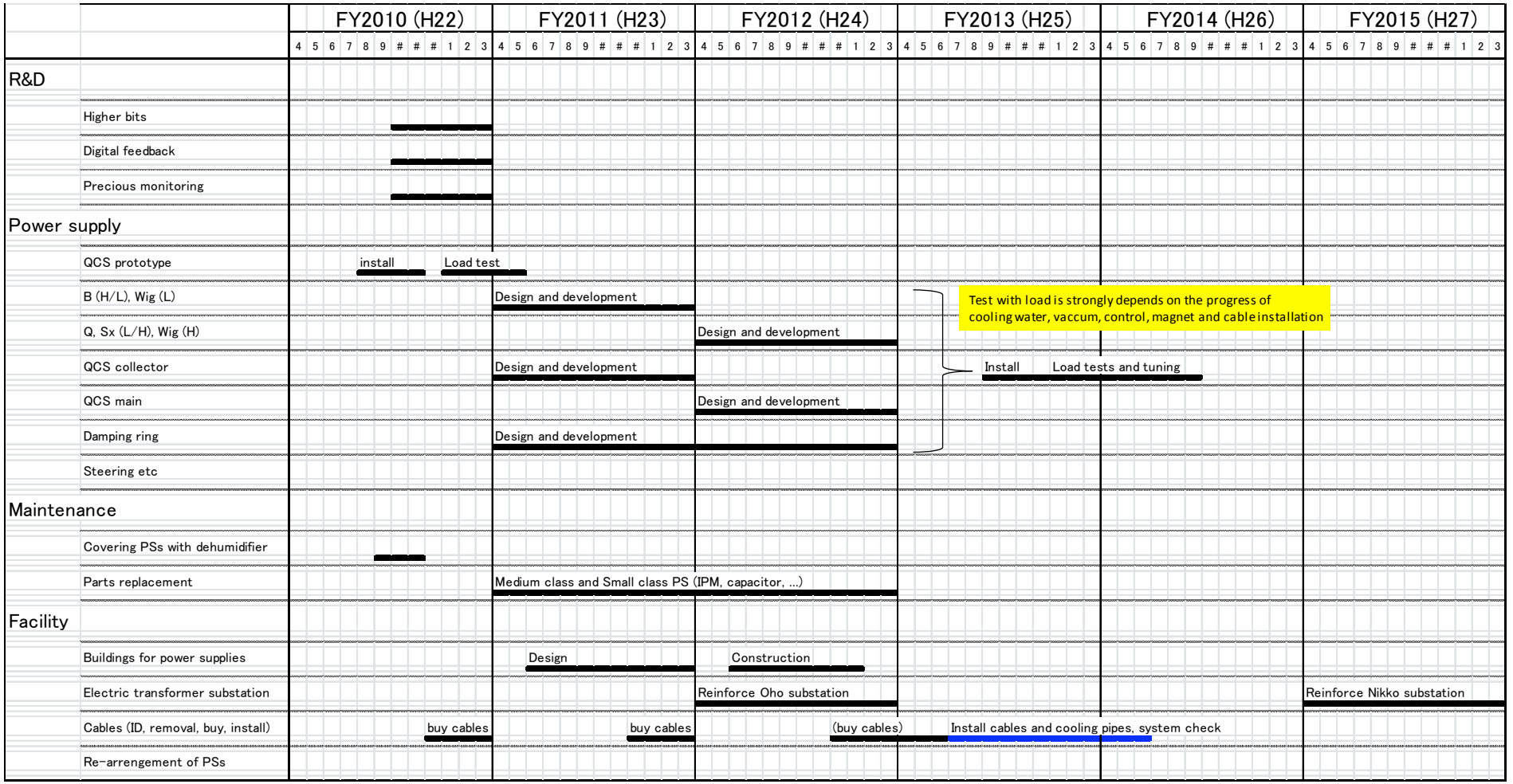


For long-term stability improvement,
precise DCCT in an oven and Digital Multi Meter
may be used for digital feed back control.

These R&D has been started and
preliminary results will be obtain until this April.

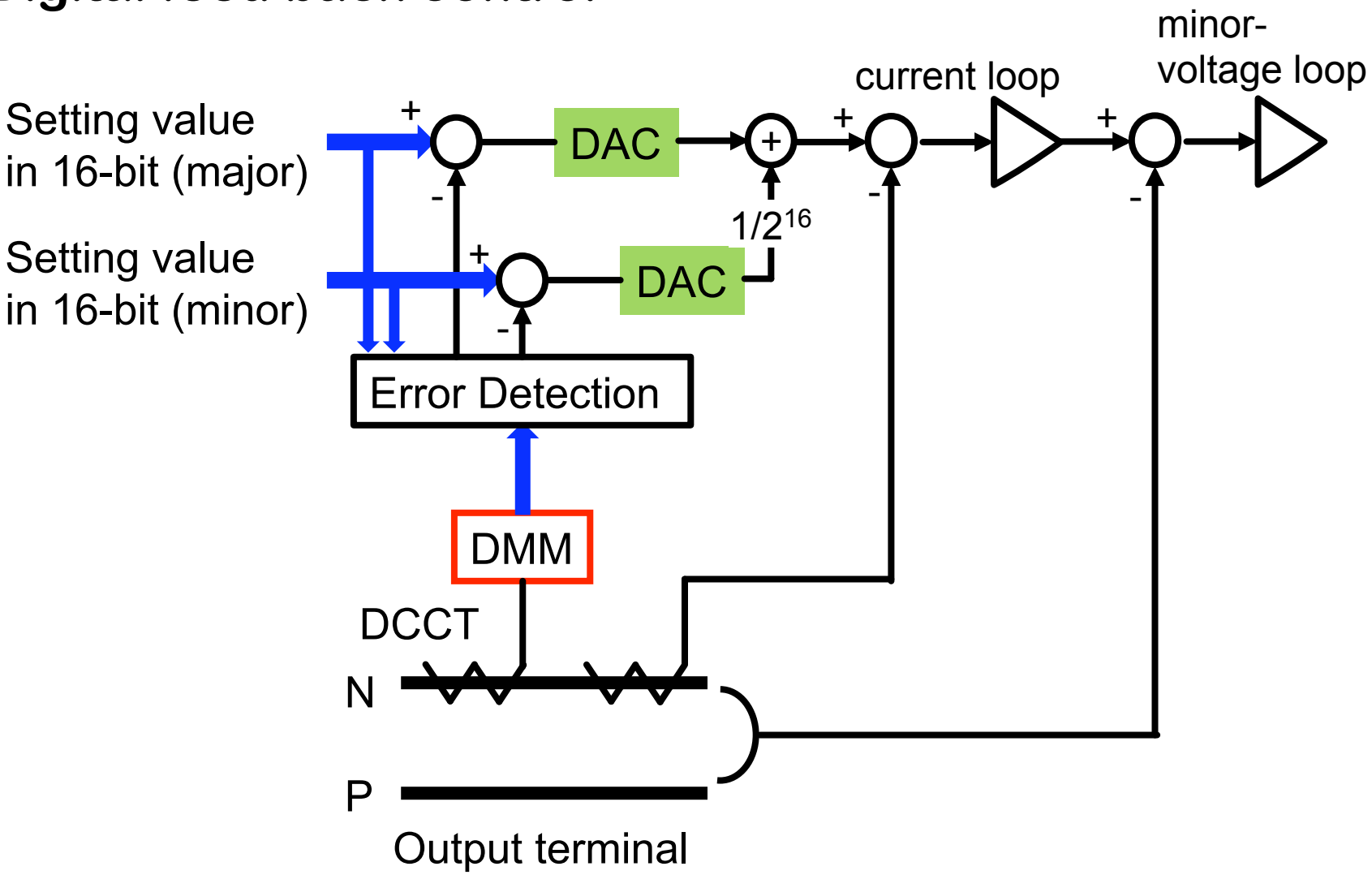
Ripple reduction study may also be required.

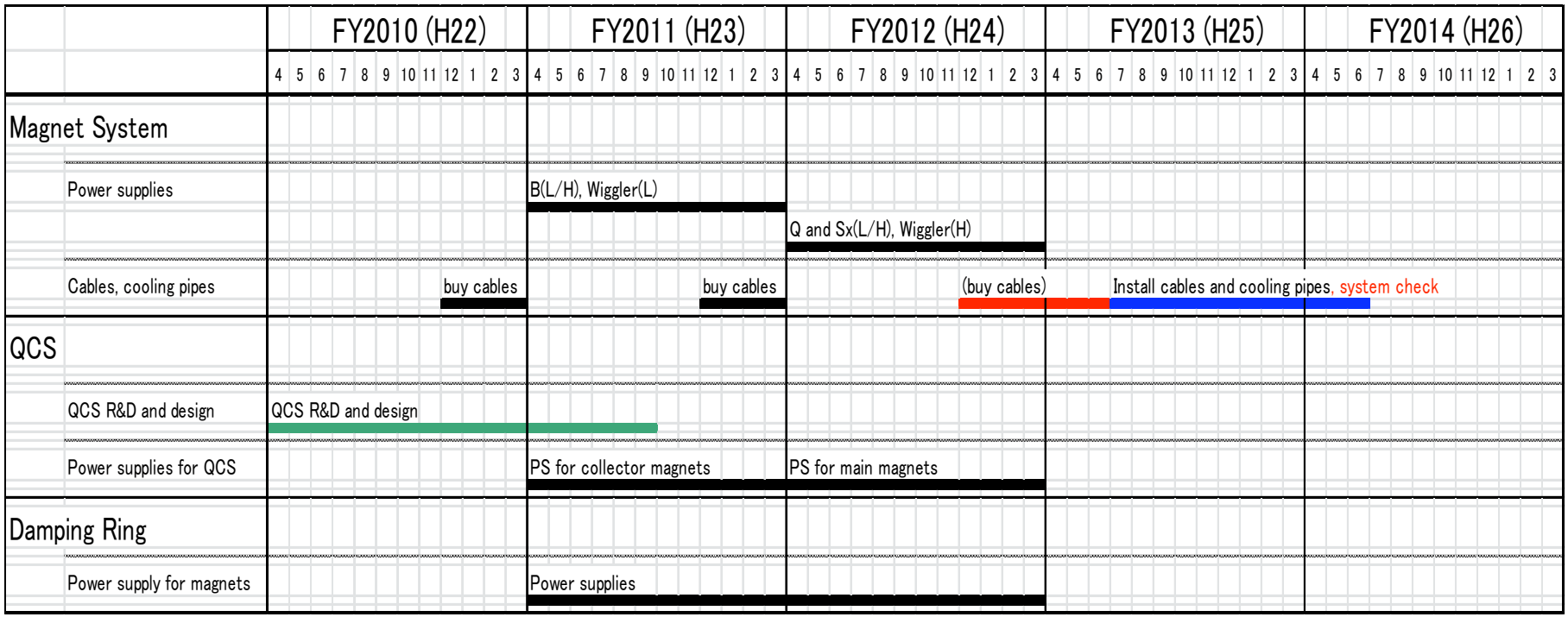
Schedule as summary



Back-up slide

Digital feed back control




FY2010 (H22)
FY2011 (H23)
FY2012 (H24)
FY2013 (H25)
FY2014 (H26)
4 5 6 7 8 9 10 11 12 1 2 3
Magnet System
Power supplies
B(L/H), Wiggler(L)
Q and Sx(L/H), Wiggler(H)
Cables, cooling pipes
buy cables
buy cables
(buy cables)
Install cables and cooling pipes, system check
QCS
QCS R&D and design
QCS R&D and design
Power supplies for QCS
PS for collector magnets
PS for main magnets
Damping Ring
Power supply for magnets
Power supplies