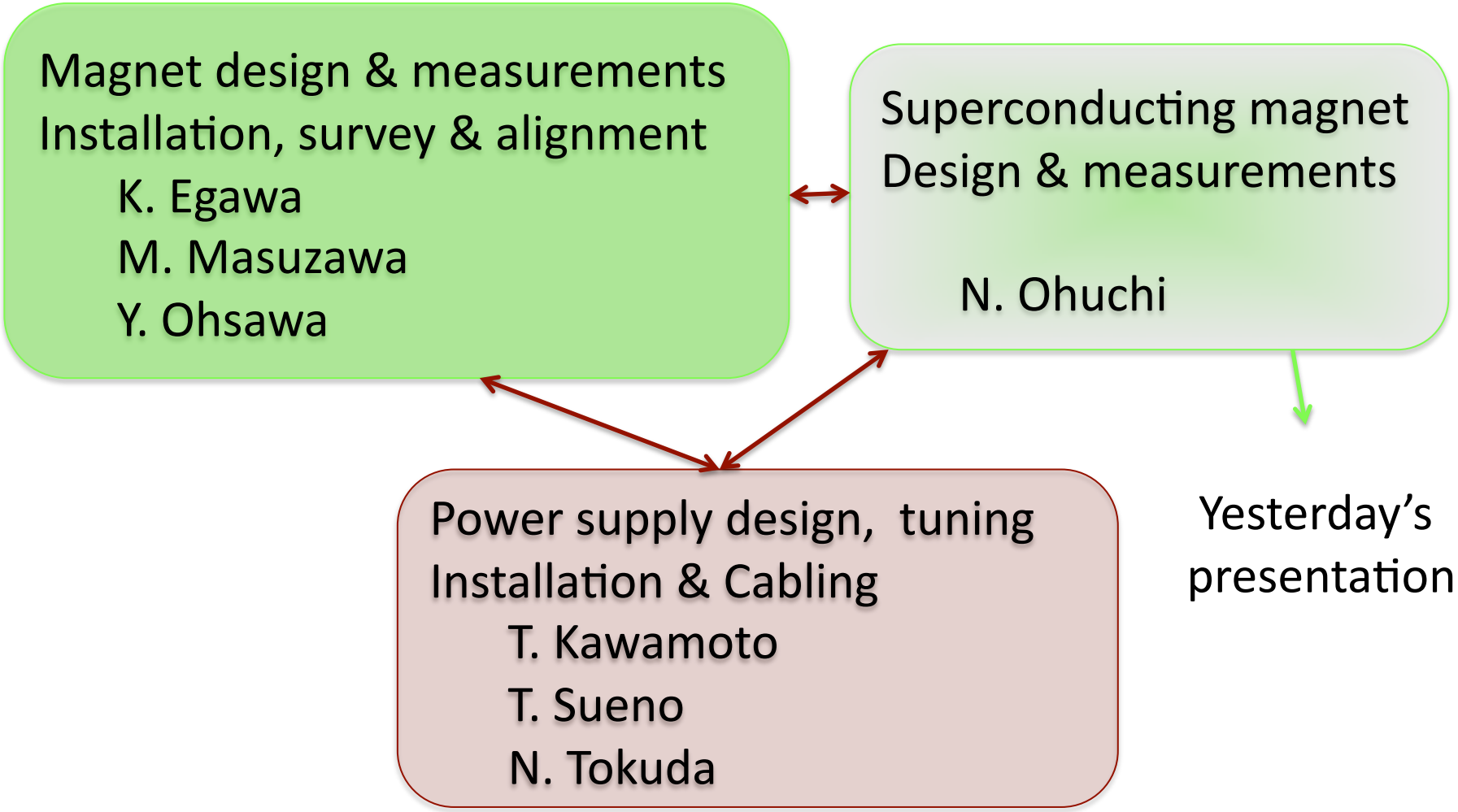
Main Ring Magnet system



Ring Magnets

Magnet design & measurements
Installation, survey & alignment

K. Egawa
M. Masuzawa
Y. Ohsawa

Impact of Nano-Beam Scheme

- Main dipole magnets need to be replaced for both HER and LER rings.
  - LER dipoles become longer (Leff 0.89 m ⇒3.99 m)
  - HER dipoles become shorter (Leff 5.91 m ⇒3.8 m)
- More wiggler magnets with shorter pole length (half pole) needed.
- More dipole, quadrupole and sextupole magnets are needed in HER since number of cells increased (~30 % more magnets).
- Cooling water system needs to be strengthened because the we will have ~30 % more magnets while we are operating the cooling water system with almost 100% capacity level already.
- Most of the magnets except for the quadrupole magnets in the two straight sections (Oho & Nikko) will be relocated to new positions. ⇒Realignment is necessary.

New magnets
& magnets need to be re-measured

Water cooled

Tolerances of the main field & multipole field errors are the same as KEKB,

is our current understanding.

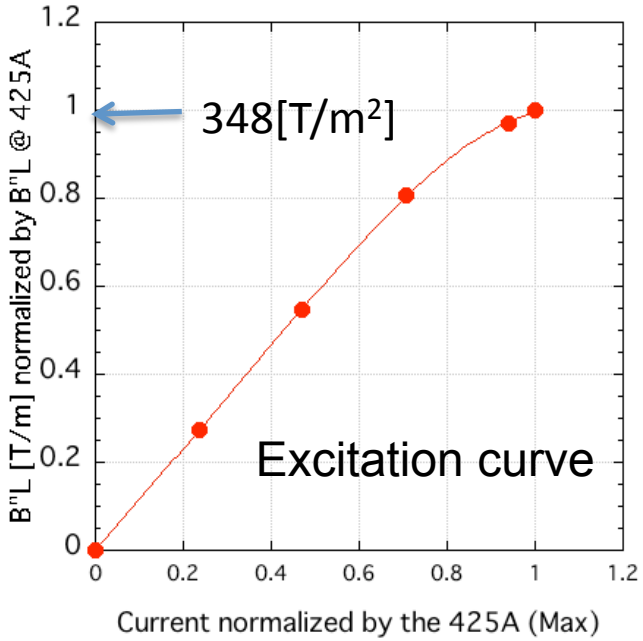
Main magnets to be designed, manufactured & measured
for SuperKEKB LER
Calculated for 4GeV

Magnet type	Mag. name	Eff. Length [m]	B or B' [T],[T/m]	counts	Comparison with KEKB
Arc dipole	B2P.*	3.99	0.1876	104	Longer weaker
Wiggler	BW0*.P	0.213	0.699	112	Half pole
Wiggler	BW1*.P	0.346	0.699	56	Single pole
Skew Quads	QK*LP	0.314	2.28	8	Longer 3 × Stronger
Quads Tsukuba section	QB3LP QB3RP (larger bore)	0.56	9.28 8.42	1 1	Same shape* ~50% stronger

*We have 43 magnets of this type but will need 44 for SuperKEKB.

Main magnets to be designed, manufactured & measured for SuperKEKB LER

Magnet type	Mag. name	Eff. Length [m]	B'' [T/m^2]	counts	Comparison with KEKB
Arc Sx	SF2TLP etc.,	0.344	So far Max. 600	# of mag >348 depends on optics 104 if all	B"=348[T/m^2]



LER arc sextupoles are already saturated at current max. of 425 A.

It seems hard to incread B" by raising the current.
Need to make new sextupole magnets.

How many?
All (104) ?
Or just the ones which exceeds 348 [T/m^2] with the most recent LER optics?

Main magnets to be designed, manufactured & measured for SuperKEKB HER (calculated for 8GeV)

Magnet type	Mag. name	Eff. Length [m]	B or B' [T],[T/m]	counts	Comments Comparison with KEKB
Arc dipole,etc.,	B2E.* ,etc.,	3.8	0.3125	144	Shorter ~20% stronger
Dipole Tsukuba	BL*LE	4.0	0.2802	14	Why not 3.8 m?
Skew Quads	QK*LE	0.373	3.238	11?	3 × Stronger
Arc quads	QF2E.* ,etc.,	1.015	8.5	80 (193)	TRISTAN QB We have 113 Still need 80.
Straight Section quads	QS5TLE ,etc.,	0.826	8.5 (@500A) ⇒~13	10	TRISTAN QA *Need to run at I > 500 A

Main magnets to be designed, manufactured & measured for SuperKEKB HER

Magnet type	Mag. name	Eff. Length [m]	B' or B'', [T/m] or [T/m2]	counts	Comments Comparison with KEKB
Straight Section quads	QL8LE etc.,	0.56	12.7 (@500A) ⇒15	7	*Need to run at I > 500A
	QL9RE etc.,	1.12	16.6	2	Newly made
	QA1LE etc.,	1.015	8.5 (@500A) ⇒8.7	14	TRISTAN QB *Need to run at I > 500 A

*Even if we are recycling the magnets, the field measurements need to be done again with larger maximum current in order to obtain an excitation curve.
And we will need new power supplies.
TRISTAN QA/QB can reach 20 T/m @1350A

Main magnets to be designed, manufactured & measured for SuperKEKB HER

Magnet type	Mag. name	Eff. Length [m]	B'' [T/m2]	counts	Comments Comparison with KEKB
Arc Sx	SF/D.*	1.0	348	88 (136)	We have 48.
Tsukuba Sx	SLYTLE.*	0.3	836	4	Super
Tsukuba Sx	SLXTLE.*	0.4	745	4	Super

Superconducting magnets at the Tsukuba straight section??

We will wait for the lattice to be finalized.

New magnets
& magnets that need to be re-measured

Air cooled

Corrector magnets

Corrector magnets to be designed, 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 ~230?	Wider gap for antechamber 160 ⇒ 290 mm
LER Horizontal for arc sec.	ZH*P	0.344	0.02	Only For QF ~230?	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 ~290?	Rotate HER ZV*P by 90° new supports

Power supplies for corrector magnets will be reused.

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.

>500 new cor. magnets

>500 new supports

Magnetic field measurements

- All new magnets
- Recycled magnets operated at higher current (than the present max. current)

Magnetic field measurements

New magnets need to be measured.

Recycled magnets with higher operating currents than the present max. current need to be re-measured with a proper standardization pattern.

Magnets to be measured:

~360 main dipoles ⇒ new flip coil system

~170 wigglers ⇒flip coil (for KEKB LER dipole)

~150 quads (probably more)⇒ harmonic coil*

~90 sextupoles (1.0m) (or more) ⇒ harmonic coil*

~104 LER sextupoles (0.34m) if newly made.⇒harmonic coil*

~600 correctors (may be more?)⇒ may have to ask the manufacturer to measure these.

Magnetic field measurements

We need:

- A new system for ~ 4 m dipoles
- New harmonic coils (or overhaul)
- Dedicated measurement area (Nikko B4)
- A measurement team, equivalent to what we had for KEKB.

Mass measurements started in Nov.1996 and lasted for about 18 months, followed by some other special measurements.

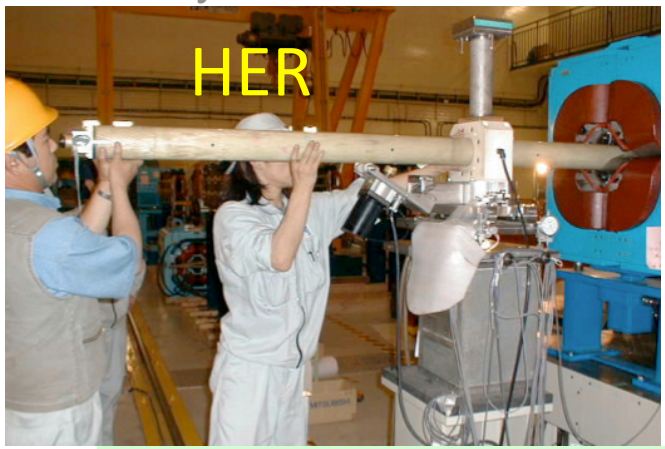
Egawa-san memo, April 1998

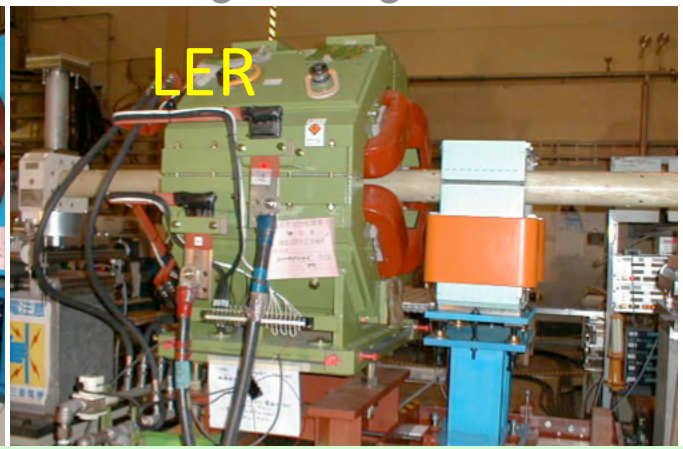
通称　日光軍団 :	Team Nikko	
・メンバー紹介　:	Members	
三菱電機：松崎　正実	M.Matsuzaki	
ATC:　金澤	Y.Kanazawa	
クリハラント：松崎　義久、生村、水野、村上（クレーン）		Y.Matsuzaki, Ikumura,Mizuno,Murakami
三菱電機システムサービス：鈴木田 (高橋)		Suzukida (Takahashi)

~7 people from companies + K.Egawa & M.Masuzawa (KEK)

Magnetic field measurements: KEKB construction

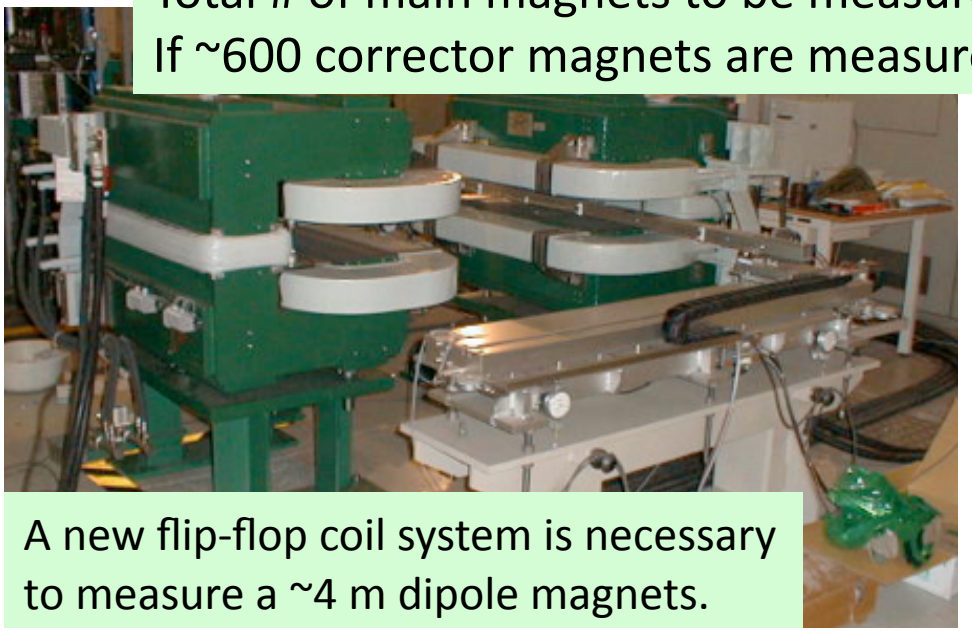
We will be measuring relatively large magnets (1~7 tons).
A couple of people adjust the magnet position to the measurement system, while others are checking the alignment.





Both HER/LER harmonic coils need an overhaul (or to be made newly).

Total # of main magnets to be measured (N) at KEK is $500 < N < 1000$,
If ~600 corrector magnets are measured outside of KEK.



A new flip-flop coil system is necessary to measure a ~4 m dipole magnets.

Cooling water system

Cooling water capacity

System we have now for KEKB

The TRISTAN pump system was reused for KEKB,

while the # of magnets doubled.

- There are ~1600 water cooled magnets in KEKB.
- A delicate balance of the flow rate among those hundreds of magnets needs to be made and maintained.
- Very susceptible to any turbulence.
- A significant amount of effort has been made to achieve stable operation.

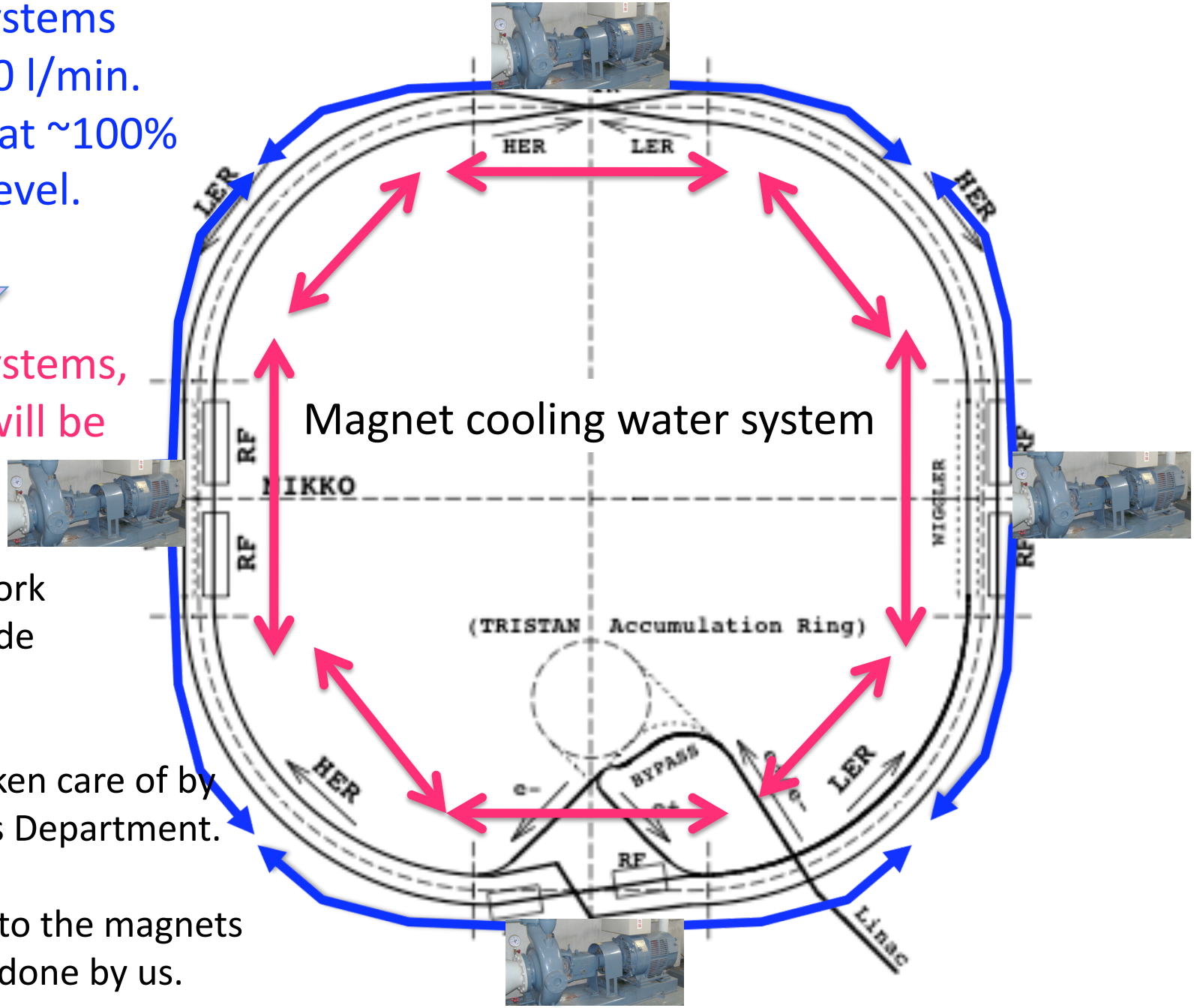
⇒ We need more water for SuperKEKB.

4 pump systems
Each~3600 l/min.
Operated at ~100%
Capacity level.

8 pump systems,
Capacity will be
doubled.

Plumbing work
outside/inside
the tunnel
is needed.
⇒will be taken care of by
the Facilities Department.

Connection to the magnets
will have to done by us.



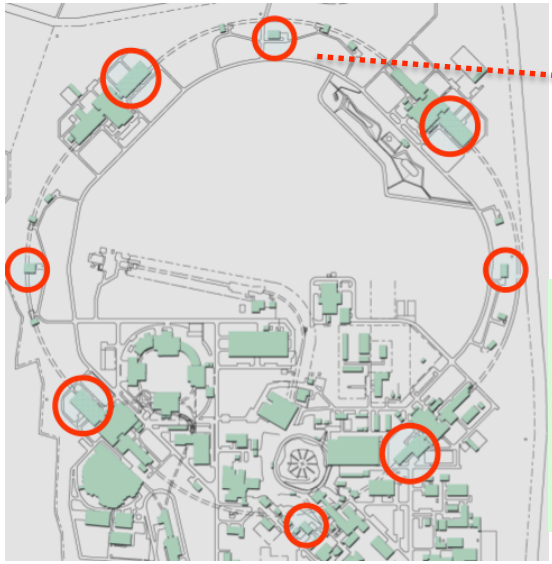
Power supplies

Power supply design, tuning
Installation & Cabling
T. Kawamoto
T. Sueno
N. Tokuda

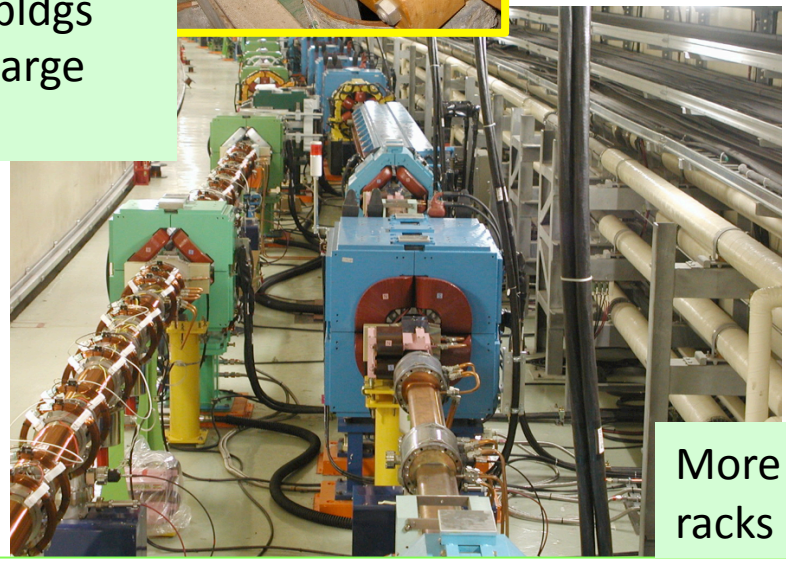
Impact of Nano-Beam Scheme

- More power supplies are needed as # of magnet families increases.
  - More space in the power supply buildings.
  - More cables from the buildings to the tunnel.
- New power supplies are needed to run at higher currents and/or with different specifications.
  - Definitely the IR magnets.
  - Power supply design will have to wait for the magnet design, which will start after the machine lattice is finalized.
- Some very old power supplies need to be replaced.
  - Most likely the power supplies for the LER/HER dipole magnets will be replaced. Wigglers?
- Cabling in the tunnel needs to be (mostly) removed & re-done
  - Remove completely or partially?
  - Magnetic cancellation due to the cables in the tunnel needs to be re-considered.

Power supply system



Thru holes between the bldgs & the tunnel large Enough?



More cable racks needed.

- 8 power supply buildings
- There are more than 2200 (~1800 for small magnets power supplies for KEKB.
- The PS buildings are already very crowded.
- We requested additional space & power receiving and distribution facilities.

The cables which we want to replace are sometimes at the bottom of everything else.
Not realistic to ID each cable and pull the cable that you want out from the rack in the tunnel.
How much of the cable we can recycle is not clear, though it affects the cost & time estimates.

Power supply system

Technical issues that we foresee:
(though the specifications have not been finalized)

More precise setting/monitoring of the current
⇒by increasing the DA/AD bits from 16 to 20(?)

Stability
- Long term stability improvement
- Ripple reduction
  - The KEKB power supplies
  - peak-to-peak ~10 ppm
  - year-to-year 10~20 ppm , pretty good actually.

But whether we can achieve this performance with new power supplies is another issue.

Control system
- Network (arcnet⇒ ?)
- Programmable Logic Controllers (PLC) interlock system upgrade.

Magnet installation & alignment

Probably more complicated operation than before (KEKB) as we will not start from scratch

(an empty tunnel).

Pros: Save on construction $$ & time of the tunnel.

Cons: Removal of the components (magnets, cables, vacuum pipes, etc) & fixing the floor surface, extra work have to take place first.

Magnet Installation

HER⇒ Lattice changes to more crowded one.
Most of the existing magnets & new magnets will be relocated to new positions, except for the quadrupole magnets in the two straight sections (Oho & Nikko) .

⇒Removal/re-installation & alignment is necessary

LER⇒ Dipole magnets replaced by longer ones.

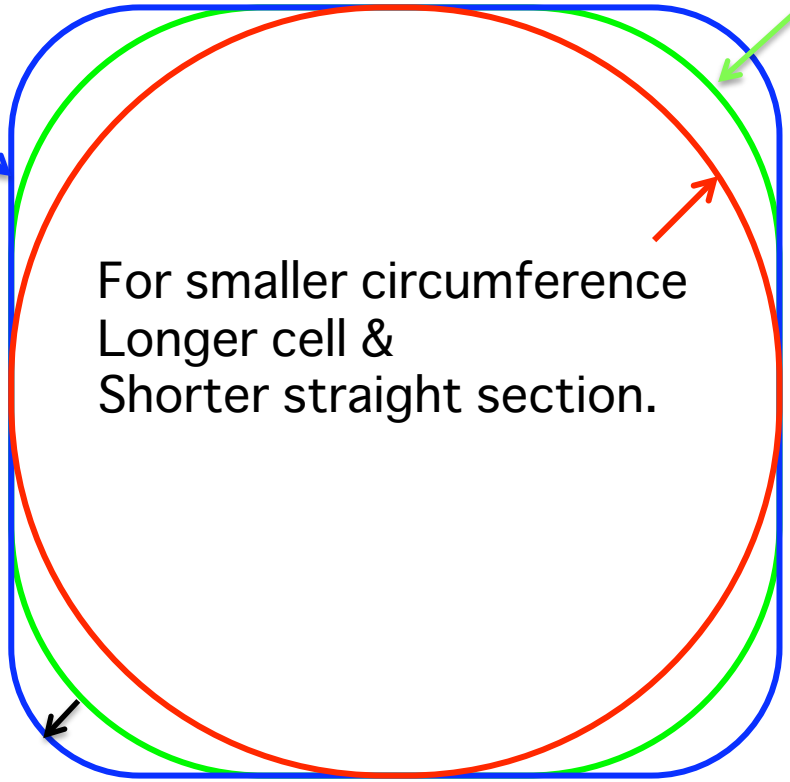
⇒ Remove the old wigglers in the two straight sections (Oho & Nikko), install old & new wigglers.

The arc lattice is the same but … with the new IR lattice, LER circumference needs to be adjusted (to that of HER & present KEKB) by the arc sections.

⇒ We have to move the magnets in the arc section.

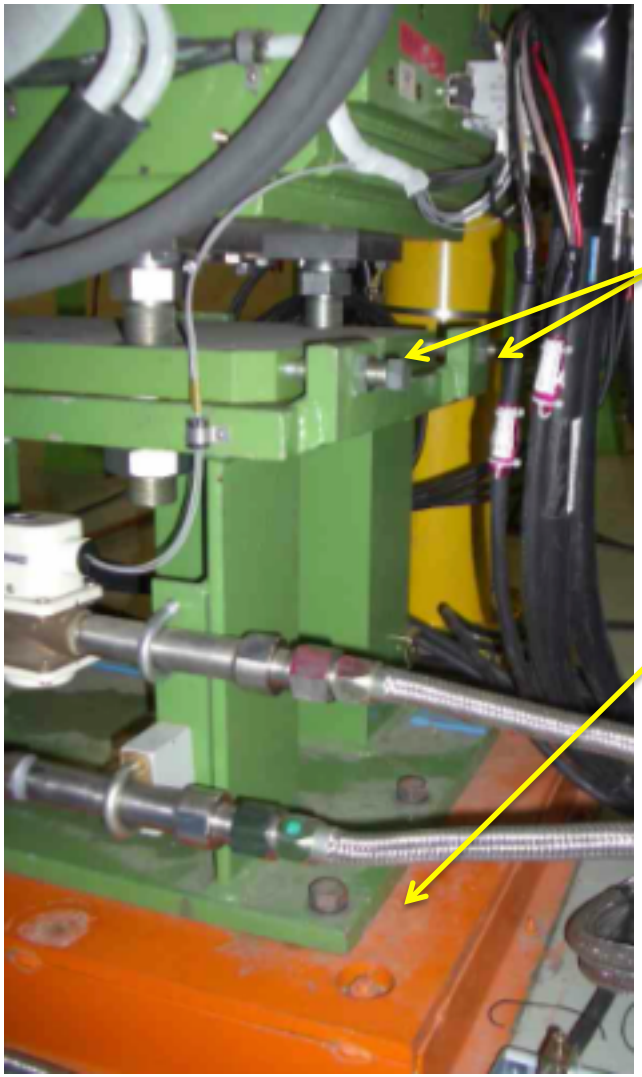
LER arc section magnets need to be moved outwards

For larger circumference
Shorter cell &
longer straight section.



Magnets in the arc sections will have to move toward out side, as much as 30 mm.

Can we shift the quadrupole magnets by ~30 mm without removing them from the base plates?



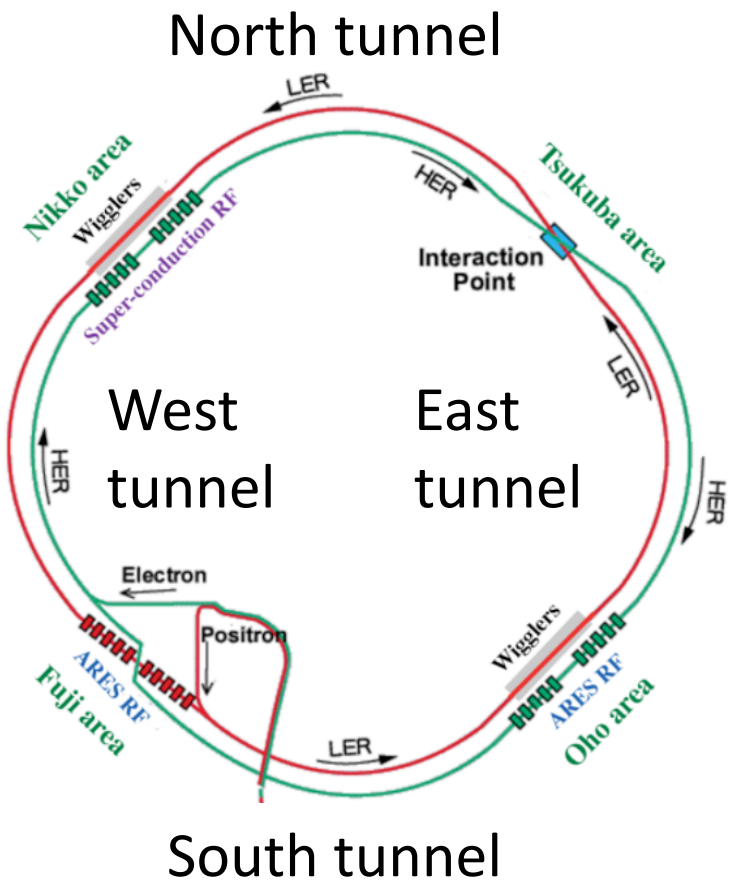
No.
Horizontal adjustments are made here but
Only up to < 20 mm (most cases 10 mm).

So we will have to remove the magnets from the (orange colored) base plates.

It is possible to make new holes around here if the shift is really only in the radial direction.

These may sound minor but a small additional work will effect the entire construction scenario & schedule.

Magnet removal (from the tunnel)



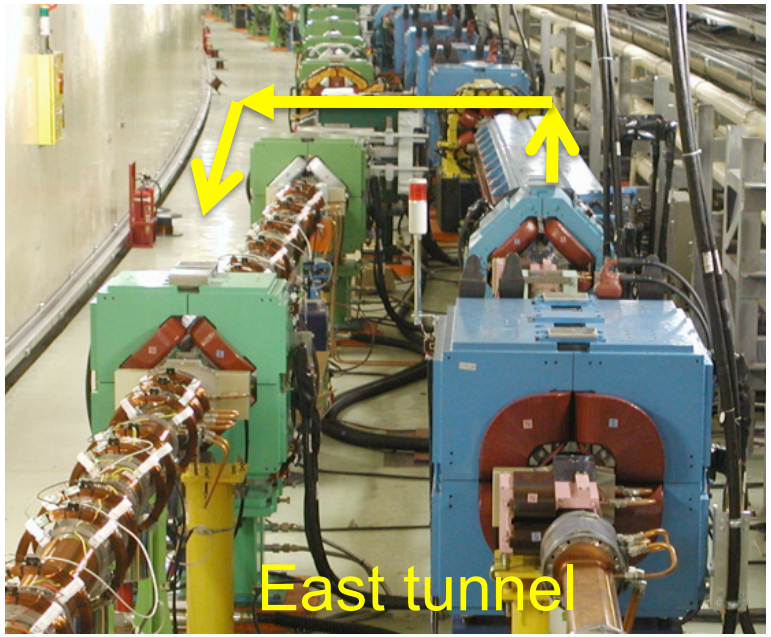
•All of the HER arc magnets (B/Q/Sx/StV/StH) & base plates have to be removed form the beam line.

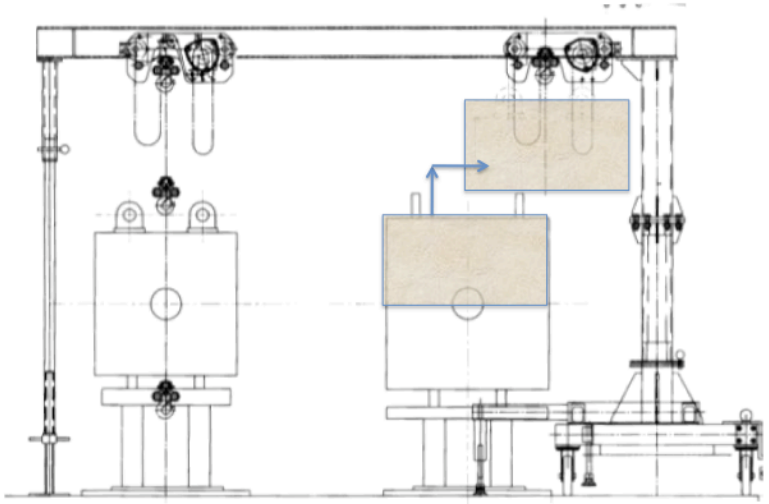
•Can LER quadrupole remain in the beam line? May be, in the West & South tunnels as LER is outer side.

•Can we remove the HER magnets in the East & South tunnels without removing the LER Q?

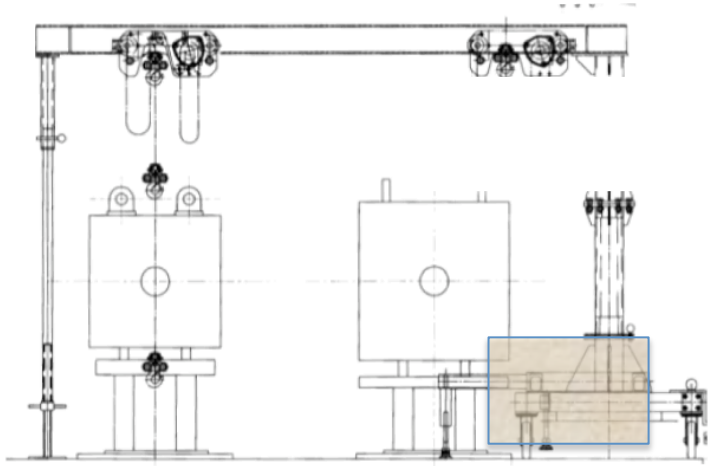
How many of the LER Q magnets can be left in the beam line?

⇒affects the construction procedure, schedule, time and cost.





(1)Magnet top is removed.



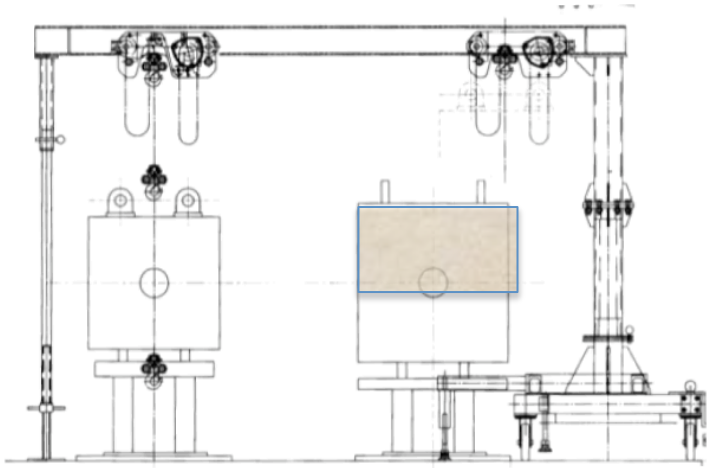
(2)Wait for the vacuum pipe
to be removed.

★ Note

Magnets can be removed only after the vacuum pipes are removed.

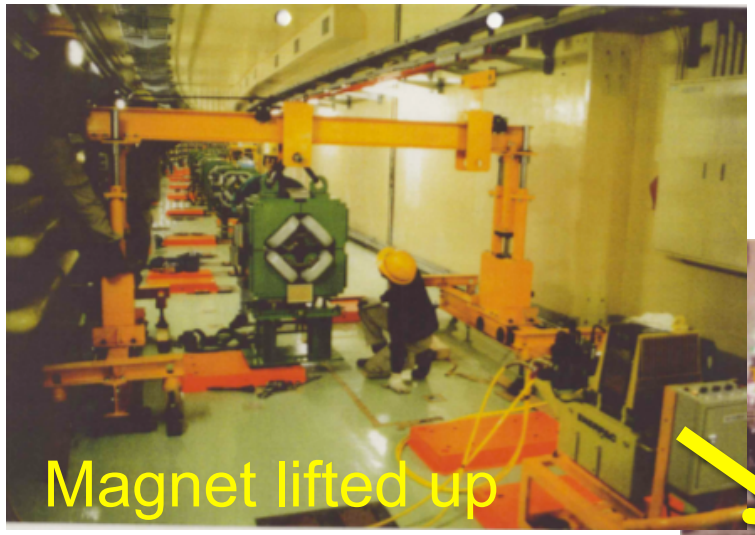
And to remove the vacuum pipes from The magnet, the magnet has “open”.

We have to this open-close operation for all HER/LER Q/Sx magnets.



(3)Magnet top is put back and bolted again
So that the entire magnet can be lifted.

Magnet removal



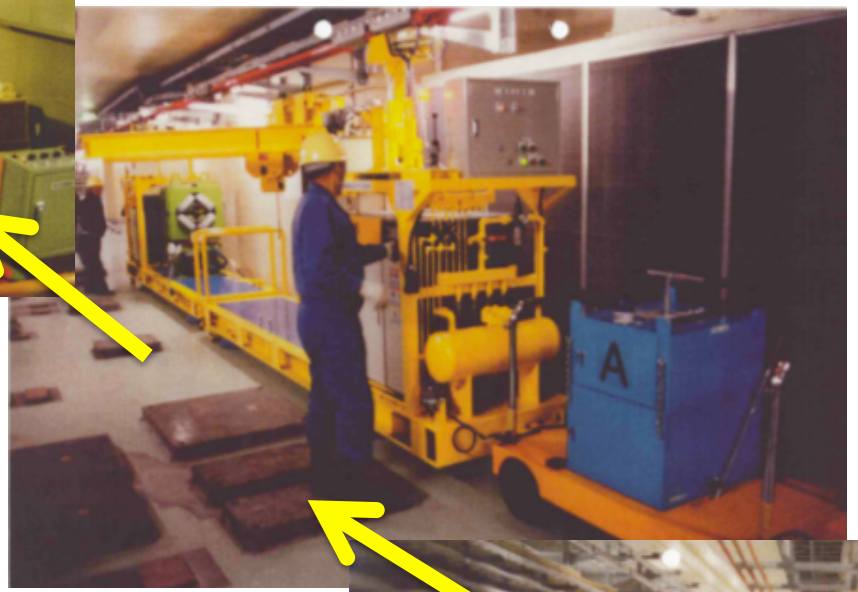
Photos are from the KEKB construction days, shown reversely.


Air pallet trolley
being overhauled.

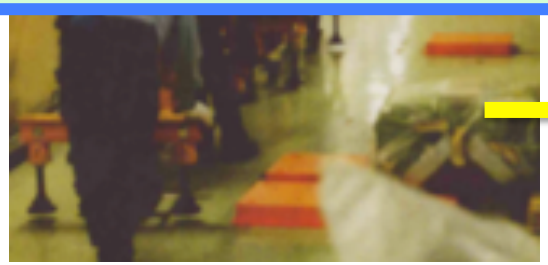

Part of the tunnel flo
needs repair/repaint

Magnet installation & alignment

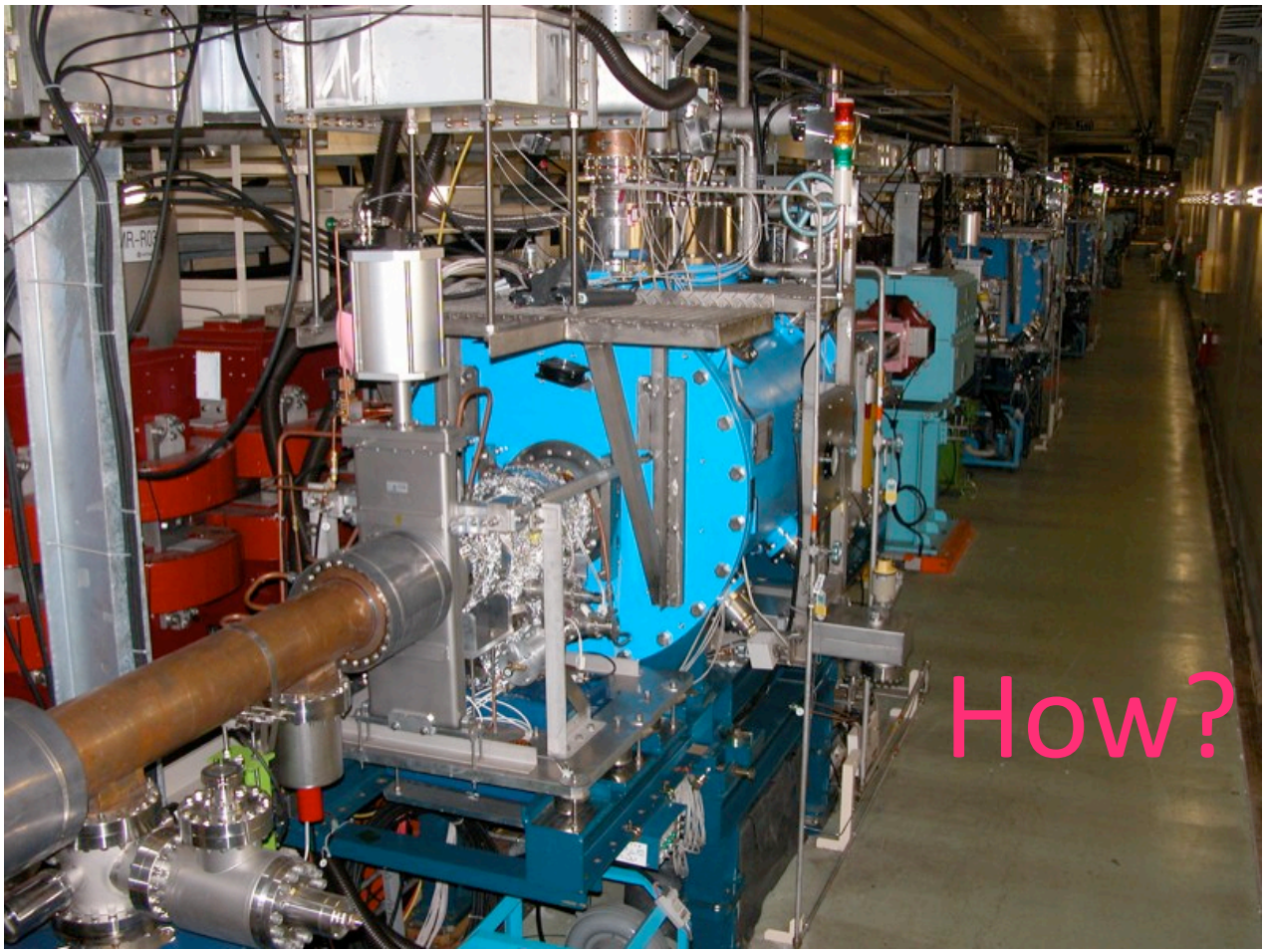
Arc section



Removing the old (orange)
base plates, repairing the floor
,surveying, marking the new beam line
& installation of the new base plates.

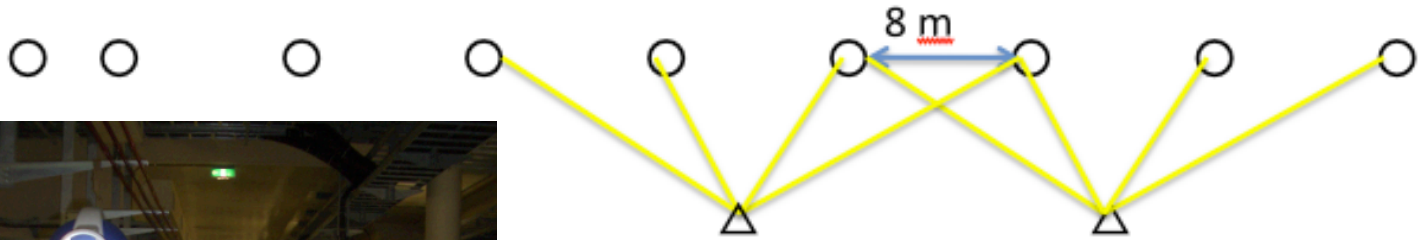


Straight sections (Oho & Nikko)
New wigglers (112 + 56) need to be installed & aligned (!)
in the straight sections while RF cavities remain…



Alignment

KEKB (TRISTAN) monuments
rather sparsely located (every ~8-10 m)
Overlap is small.



In order to enforce the tracker networking, we are adding more monuments to the wall and etc., and surveying them. We hope to obtain a stronger tracker network for SuperKEKB.
New tracker performance test, also.

Floor motion monitor system

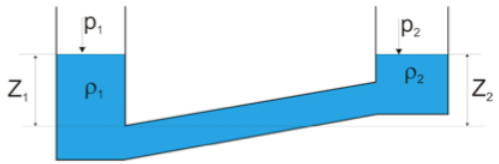
The 9th ATF2 Project Meeting December 14 – 17, 2009

What is HLS?

HLS Principle (1)

Hydrostatic Leveling Systems are based on the principle of communicating vessels or more precisely on the equilibrium of the pressure of the fluid in the communicating vessels. This is mathematically described by the Bernoulli equation.

$$p + g \rho Z = \text{const.}$$



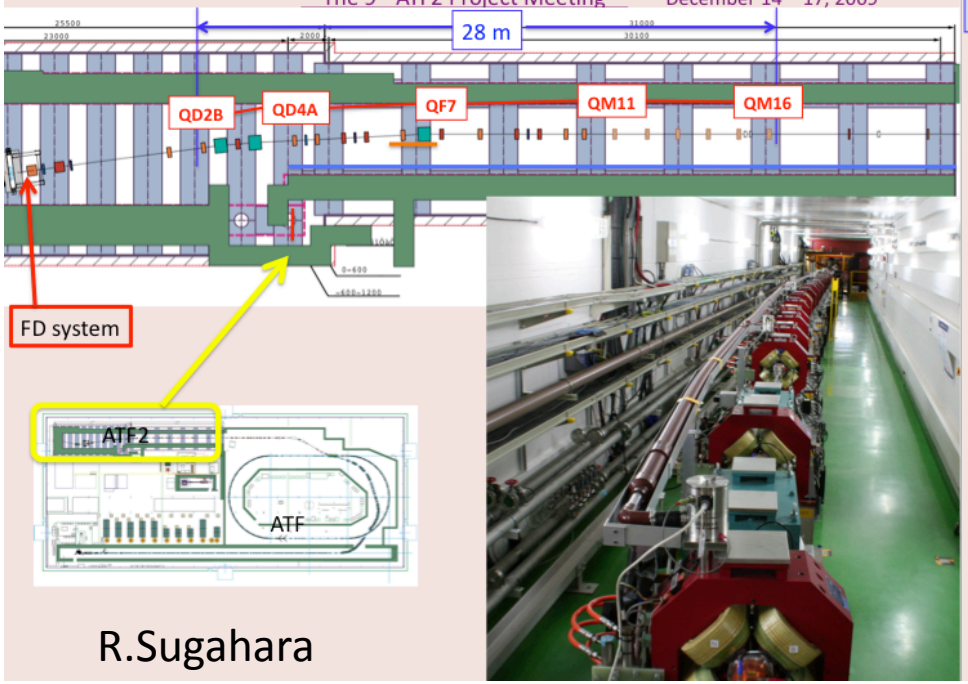
$\Delta p = 0.10$ hPa => $\Delta Z = 1.02$ mm

ΔTemp = 1°C; Z = 100 mm => $\Delta Z = 67$ μm

We will install HLS sensors in the KEKB tunnel (IR) in order to monitor a level change over time.

We obtained 5 HLS sensors from SLAC (thanks to R.Ruland, G.Gassner & A.Seryi) and installed them in the ATF2 beam line.

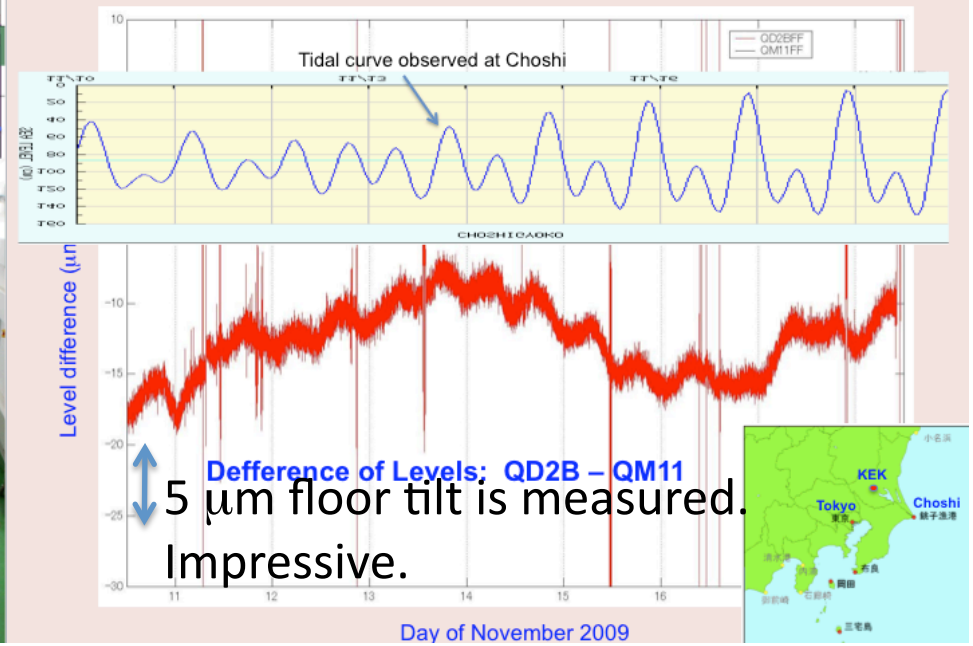
The 9th ATF2 Project Meeting December 14 – 17, 2009



R.Sugahara

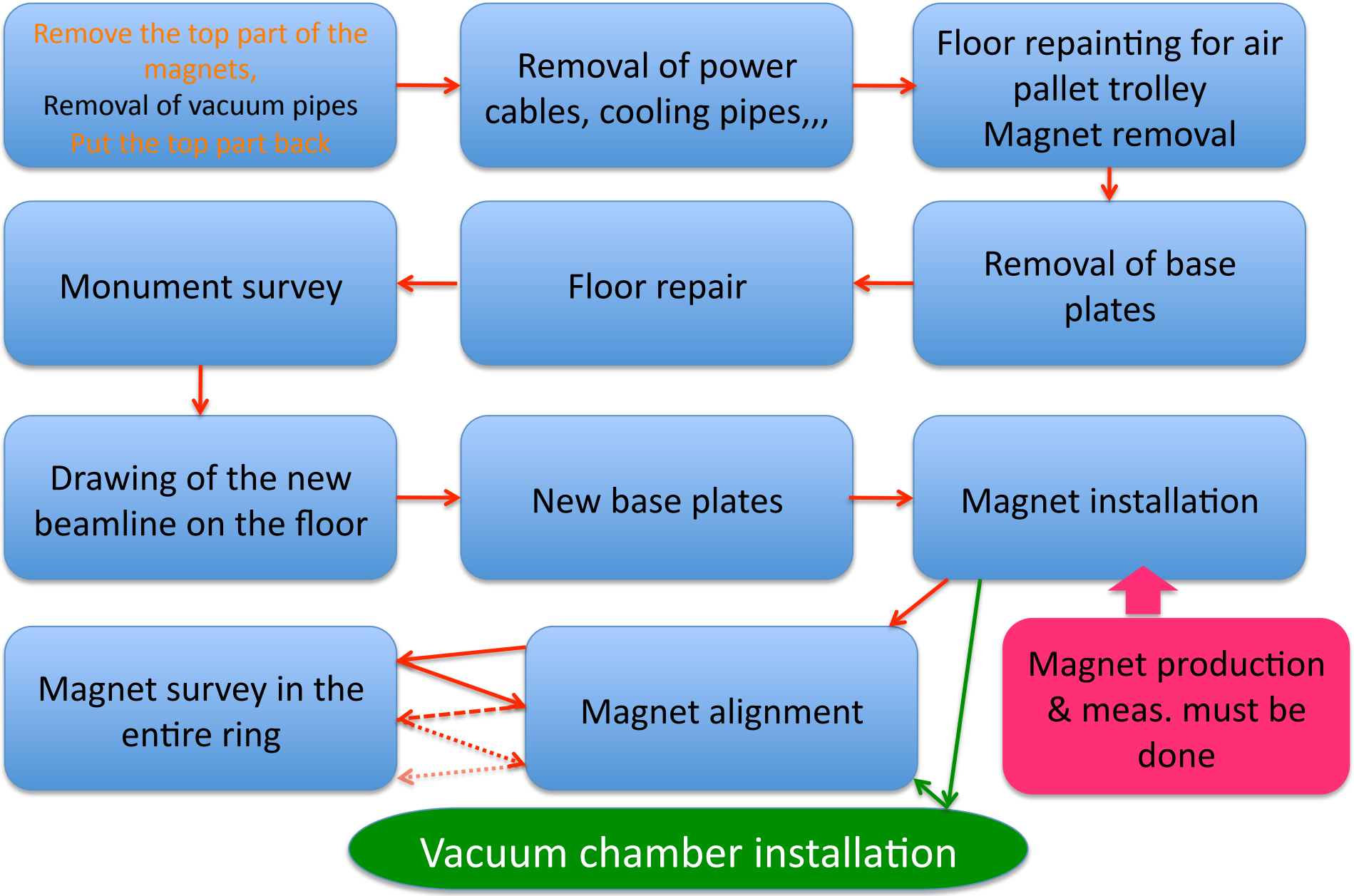
The 9th ATF2 Project Meeting December 14 – 17, 2009

Observation 2: Earth tide and the tilt of the floor



5 μm floor tilt is measured. Impressive.

Construction



Summary

Magnet design & measurements Installation, survey & alignment
K. Egawa
M. Masuzawa
Y. Ohsawa

Power supply design, tuning Installation & Cabling
T. Kawamoto
T. Sueno
N. Tokuda

- The switch to the nano-beam scheme created a huge impact on the amount of work.
- We wait for the lattice to be finalized so that we can start working on making a construction schedule.
- More complicated scheduling and arrangements seem to be required among groups.

Will magnet production, measurements, power supplies, cabling, installation, alignment, etc., all be completed in time?

Help, I need somebody
Help, not just anybody
Help, You know I need someone…