The SuperKEKB Accelerator Status

M.Iwasaki (KEK)
for the SuperKEKB accelerator group

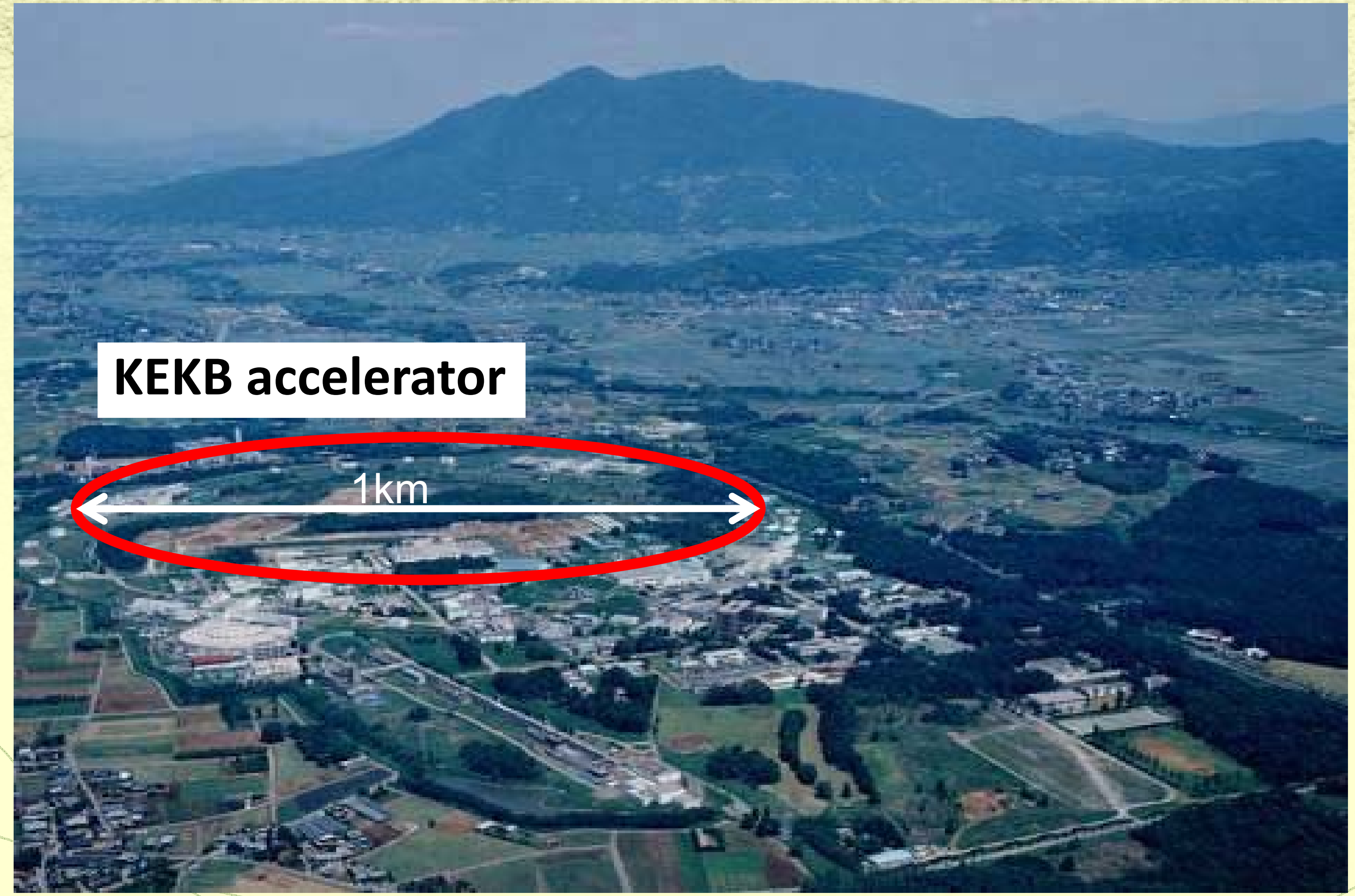
KEKB to SuperKEKB : current status

- **KEKB** operation finished at 9:00 am June 30, 2010

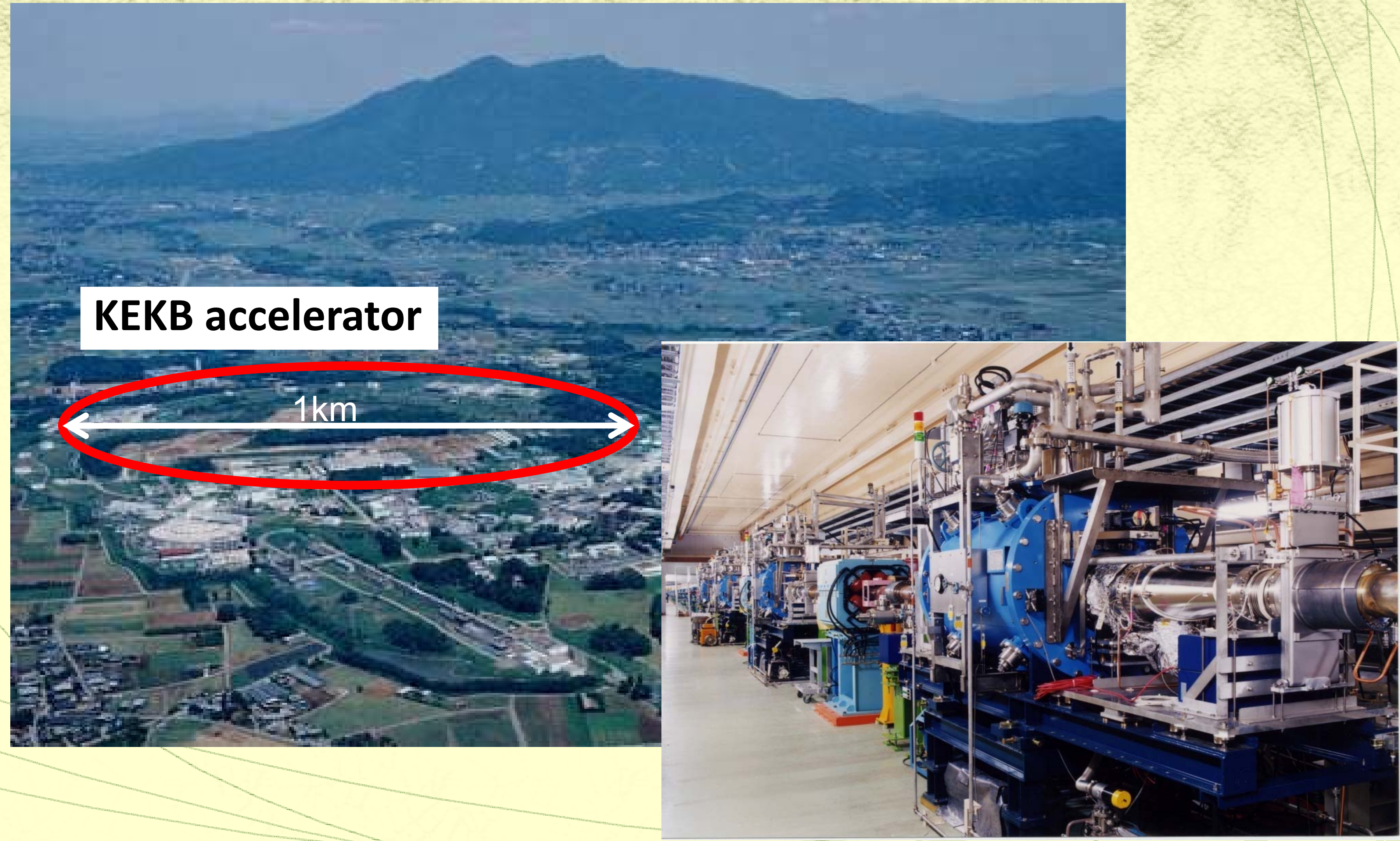
- **SuperKEKB** budget is partially approved
  - Damping ring : 580M yen (~5.8M$) (FY2010)
  - Special budget "Very Advanced Research Support Program"
    1B yen (~100M$) (FY2010-2012)

→***<u>Start construction</u>* (FY2010-2013)**

KEKB to SuperKEKB



KEKB to SuperKEKB



KEKB to SuperKEKB

The KEKB B-factory in Japan

More than1ab^{-1} data / 11 years

The world highest luminosity

KEKB to SuperKEKB

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→***Will be upgraded to <u>SuperKEKB</u>***

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More than1ab^{-1} data / 11 years

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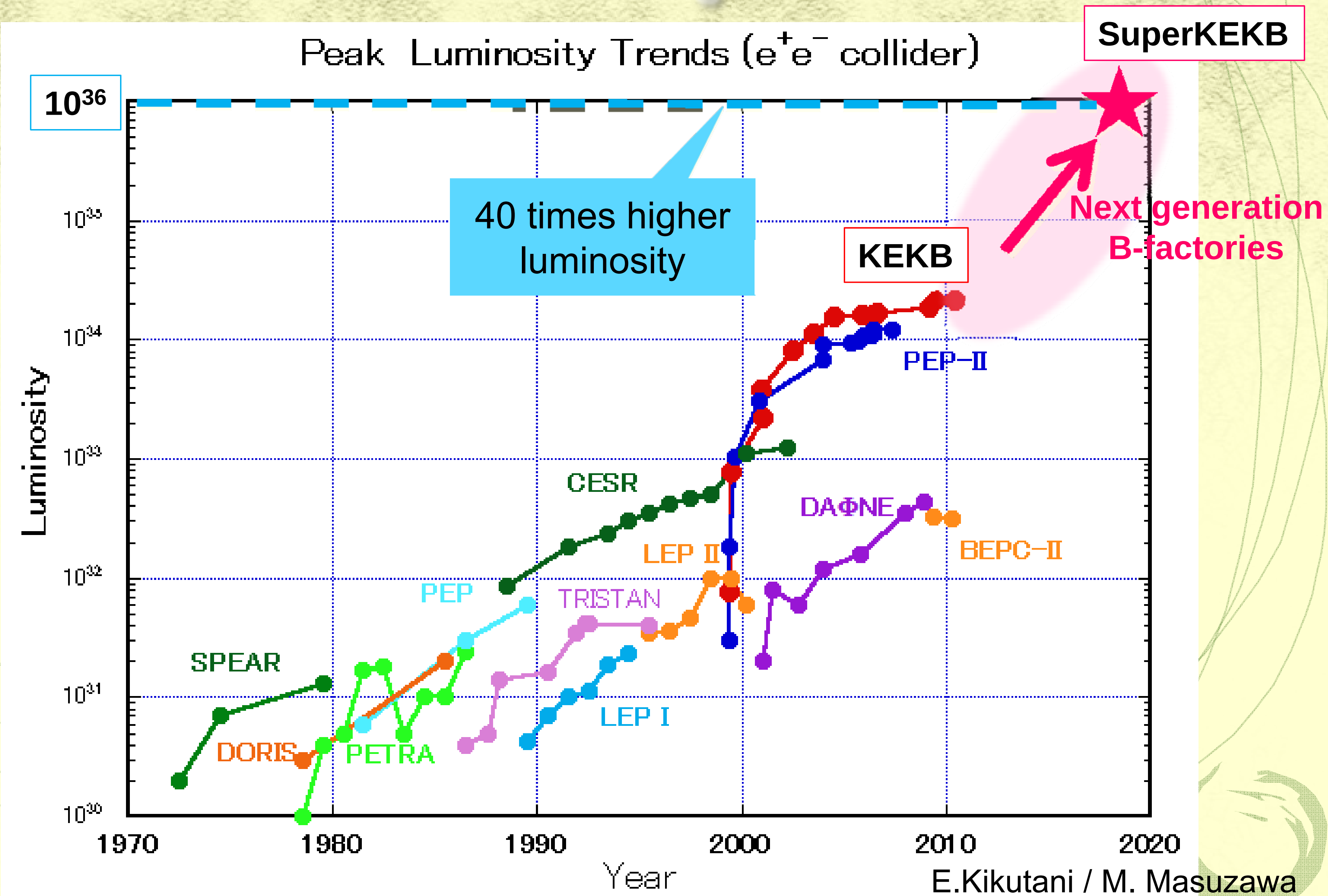
→***Will be upgraded to <u>SuperKEKB</u>***

<u>X40 higher luminosity</u>

KEKB to SuperKEKB



Strategies for increasing Luminosity

Beam-beam parameter

Lorentz factor

Beam current

$$L = \frac{\gamma_{e\pm}}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\left(\frac{I_{e\pm}\xi_y^{e\pm}}{\beta_y^*}\right)\left(\frac{R_L}{R_{\xi_y}}\right)$$

Lumi. reduction factor (crossing angle)& Tune shift reduction factor (hour glass effect) 0.8 ~ 1 (short bunch)

Classical electron radius

Beam size ratio@IP 1 ~ 2 % (flat beam)

Vertical beta function@IP

(1) Smaller β_y^*

(2) Increase beam currents

(3) Increase ξ_y

“Nano-Beam” scheme

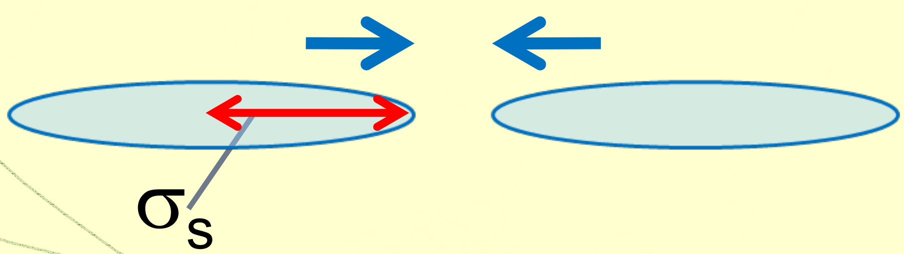
Collision with very small spot-size beams

Nano-Beam scheme

- First proposed by P.Raimondi for SuperB
- To increase luminosity, **squeeze beams to nanometer scale**
- However, squeezing beams in stronger magnetic field saturated by **hourglass effect**

→ **Enlarge crossing angle**
and intersect bunches only at highly focused region

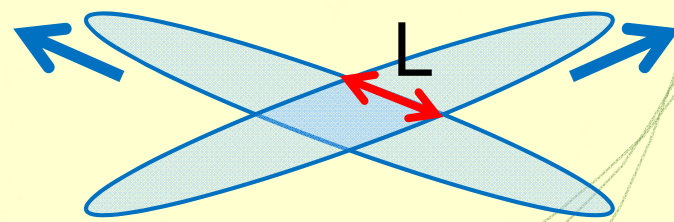
Head-on collision



overlap region = bunch length

Hourglass condition: $\beta_y^* > \sim\sigma_s$

Nano-beam scheme



overlap region ~L

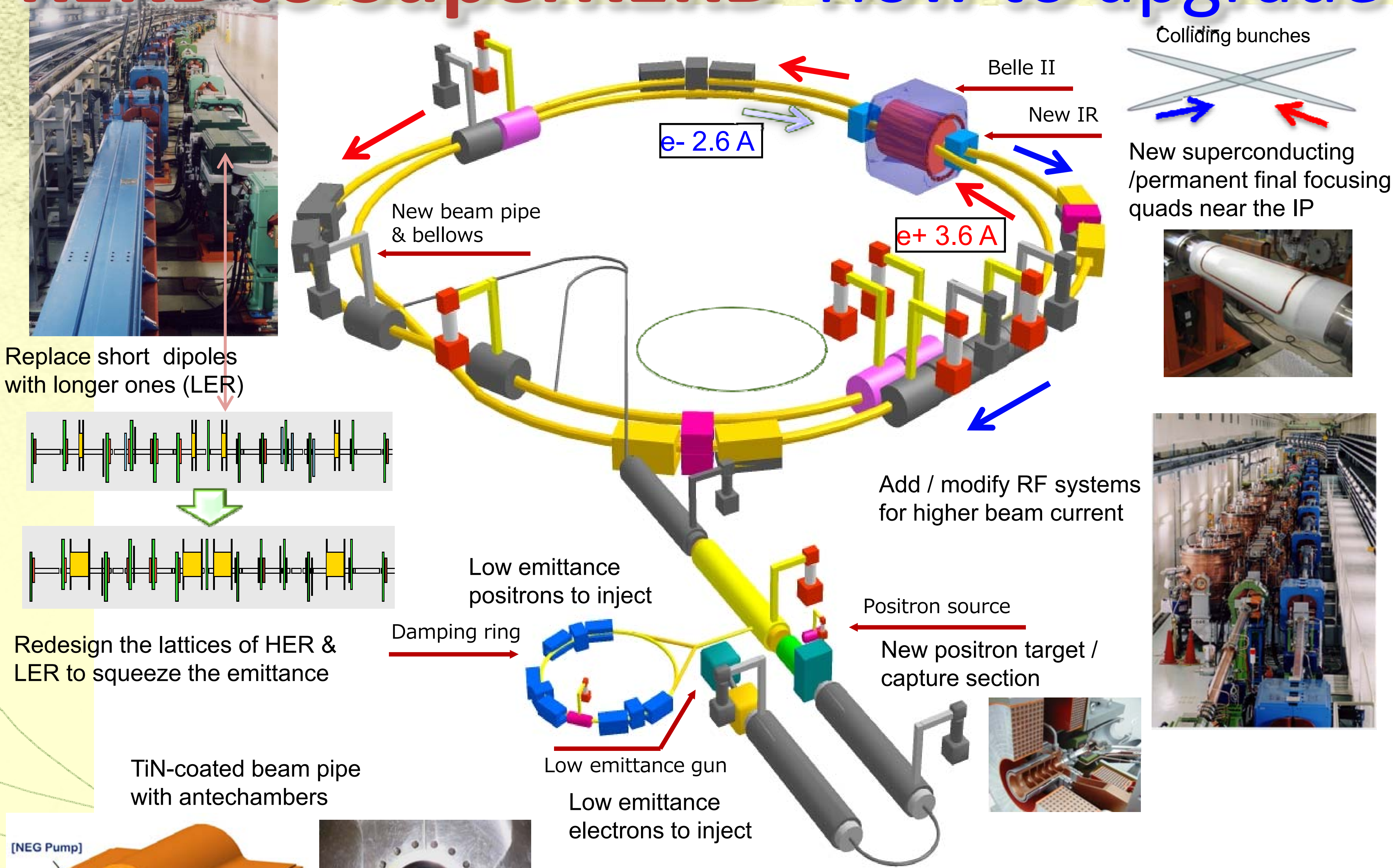
Hourglass condition: $\beta_y^* > \sim L$

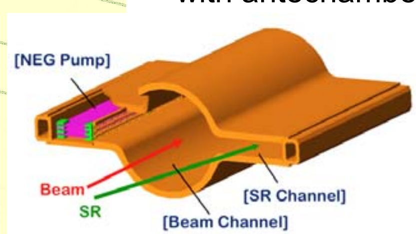
Machine Design Parameters

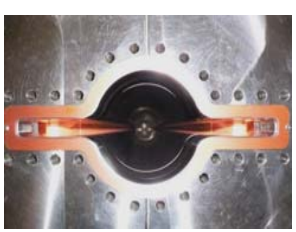
parameters		KEKB		SuperKEKB		units
		LER	HER	LER	HER	
Beam energy	E_b	3.5	8	4	7	GeV
Half crossing angle	φ	11		41.5		mrad
Horizontal emittance	ε_x	18	24	3.2	5.0	nm
Emittance ratio	κ	0.88	0.66	0.27	0.25	%
Beta functions at IP	β_x^*/β_y^*	1200/5.9		32/0.27	25/0.31	mm
Beam currents	I_b	1.64	1.19	3.60	2.60	A
beam-beam parameter	ξ_y	0.129	0.090	0.0886	0.0830	
Luminosity	**L**	**2.1×10^{34}**		**8×10^{35}**		$cm^{-2}s^{-1}$

- **Small beam size & high current** to increase luminosity
- **Large crossing angle**
- **Change beam energies** to solve the problem on LER short lifetime

KEKB to SuperKEKB How to upgrade







To get x40 higher luminosity

Major items to upgrade

- New Ante-chamber beam pipes

Mitigation techniques for suppression of electron cloud.

- New IR design

New superconducting/permanent magnets around IP.

Optimization of the compensation solenoid.

Local Chromaticity correction sections for both rings.

- New low emittance optics for both e^+e^- rings

Replace dipoles & change the wiggler layout for positron ring

- New low emittance beam injections

New damping ring and target for positrons / New RF gun for electrons

- Higher beam currents

Add / modify the RF systems

- Precise beam diagnostics and tunings

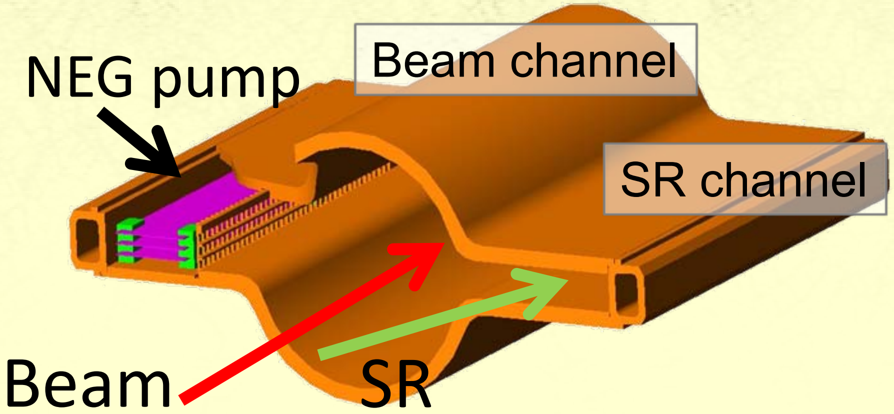
More precise magnet setting ⇔ power supplies.

New Ante-chamber beam ducts

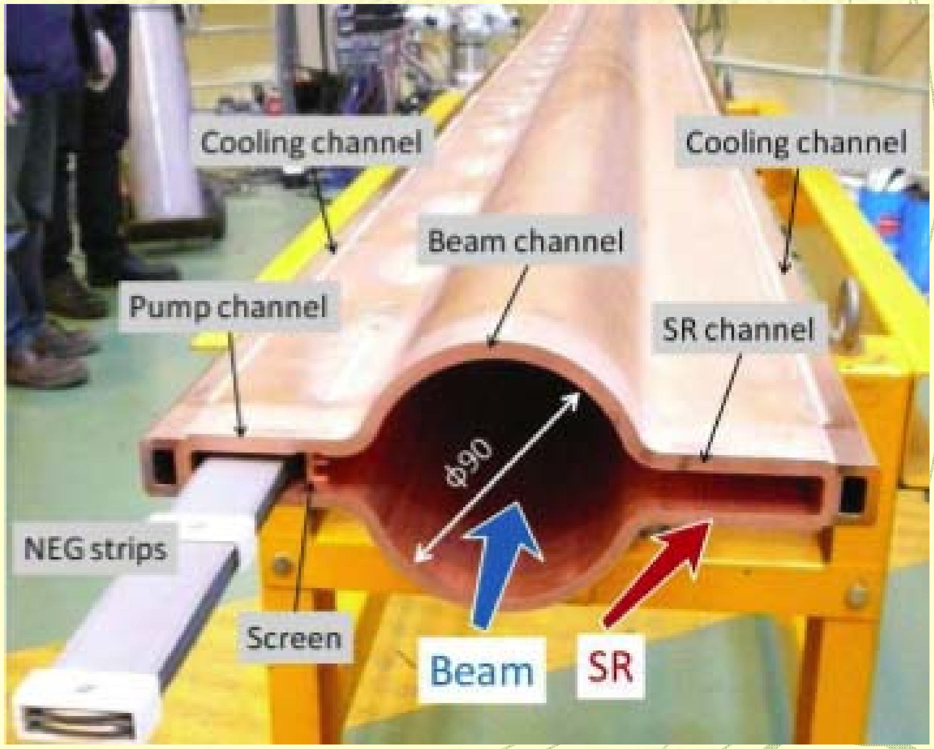
TiN-coated beam ducts with ante-chambers

to suppress - Heating of components : HOM and SR
- Electron cloud instability

Y.Suetsugu



- Low SR power density
- Less photoelectrons in beam pipe
- Low beam impedance



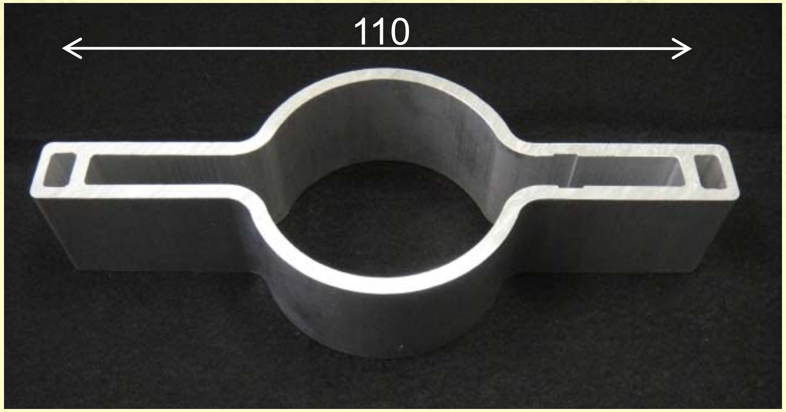
Copper duct to withstand intense SR power

New Ante-chamber beam ducts

In the place with less SR power,
Aluminium beam ducts will be installed

Aluminum-alloy duct

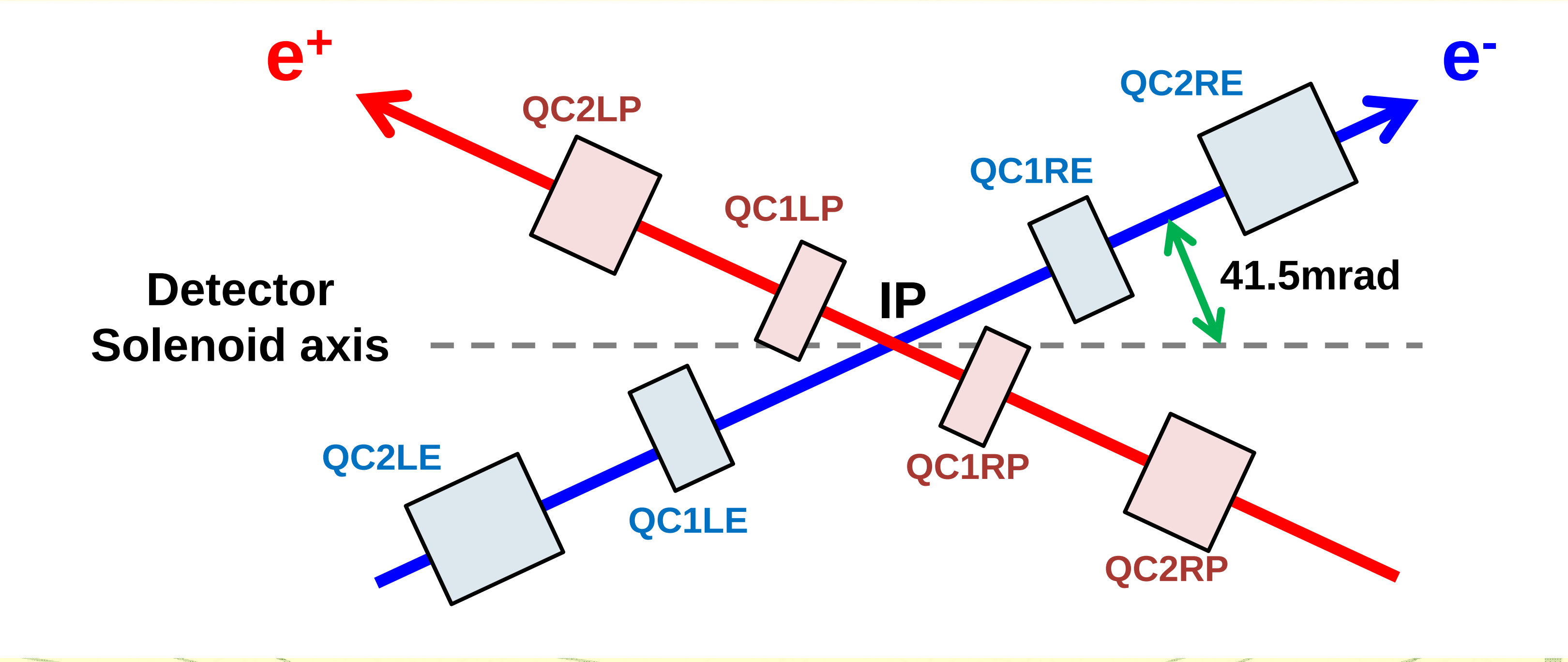
Y.Suetsugu



New IR design based on the Nano-beam scheme

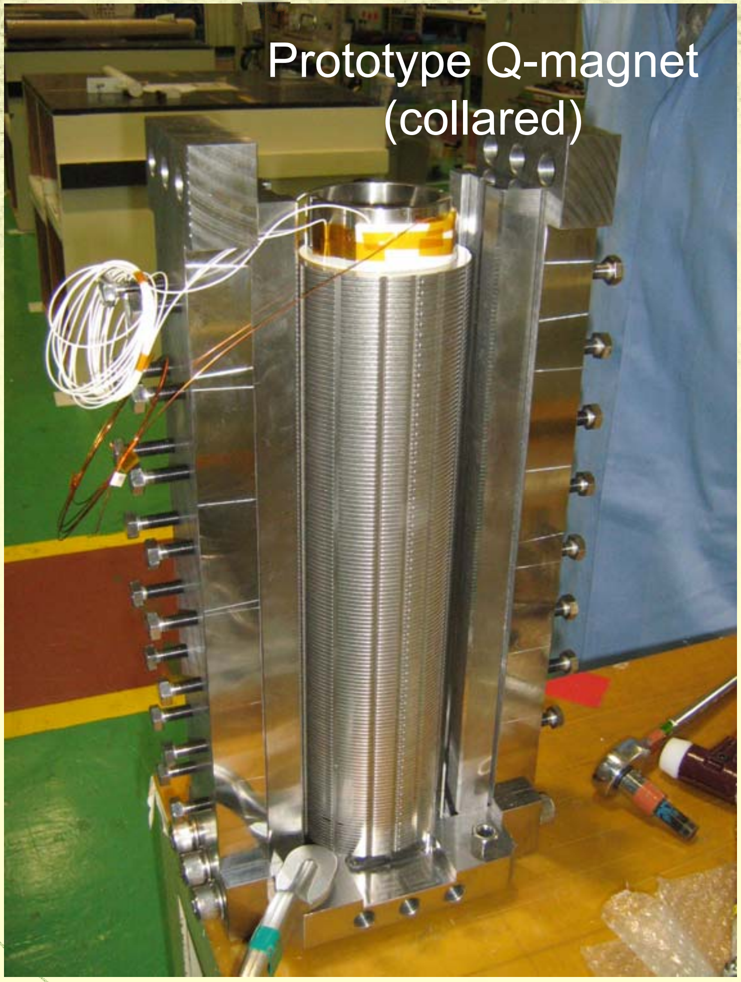
New Final-Focusing system

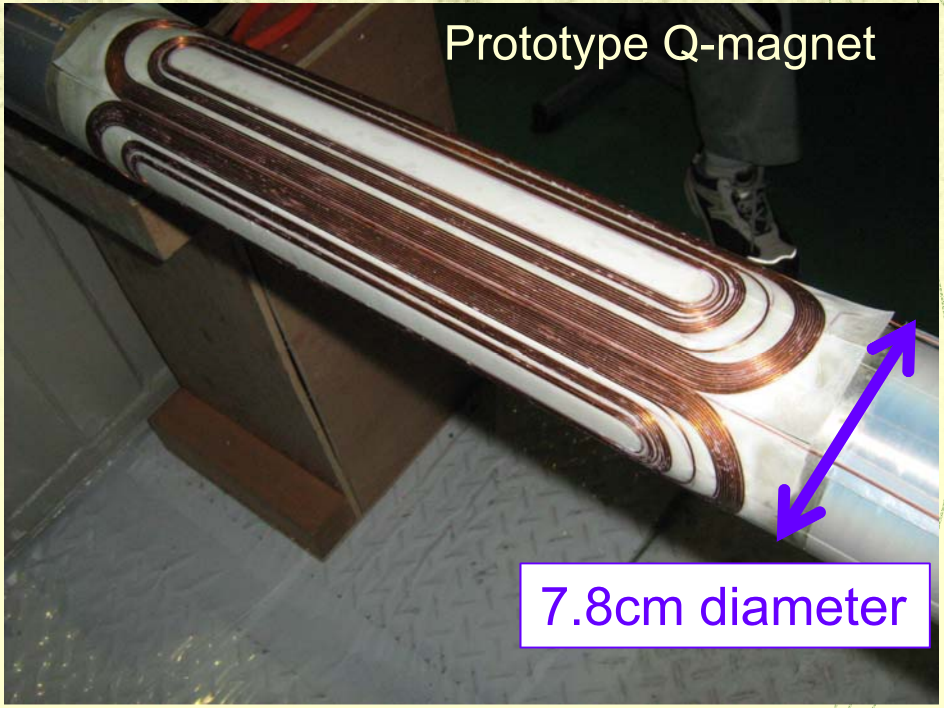
- Consists with superconducting and permanent magnets
- Final focusing Q-magnets for each beam
- Crossing angle 83 mrad to make the FF magnets close to IP



Superconducting Magnet R&D

N.Ohuchi





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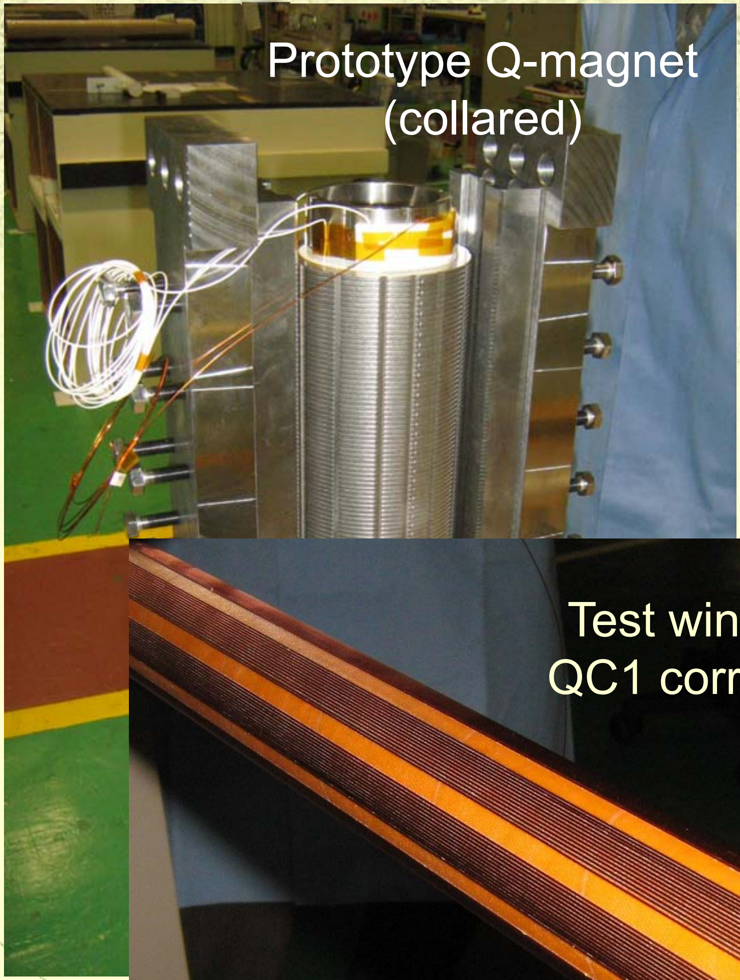
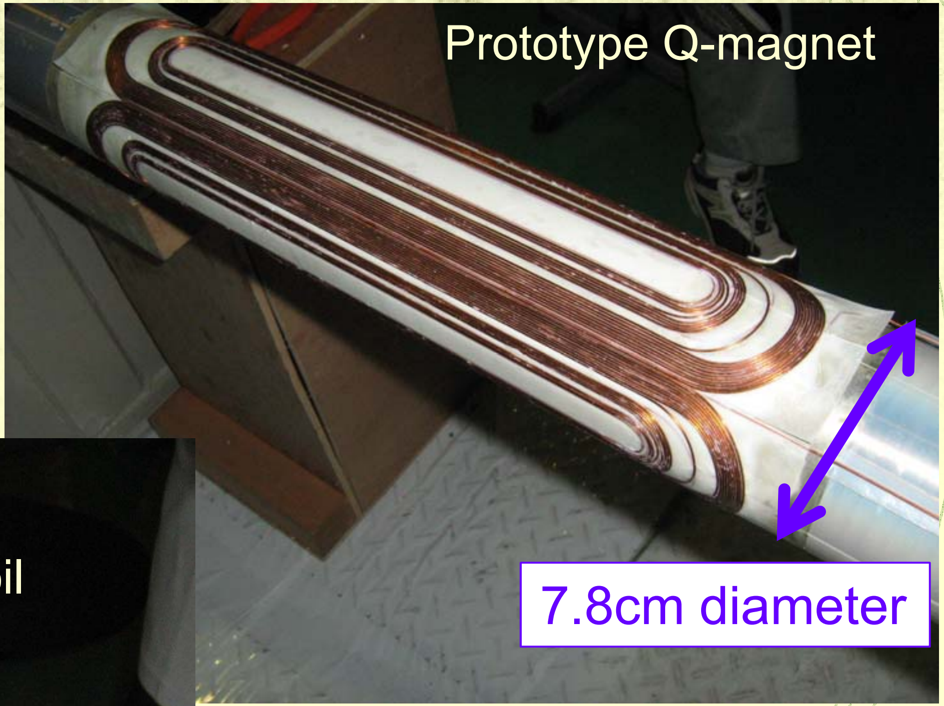
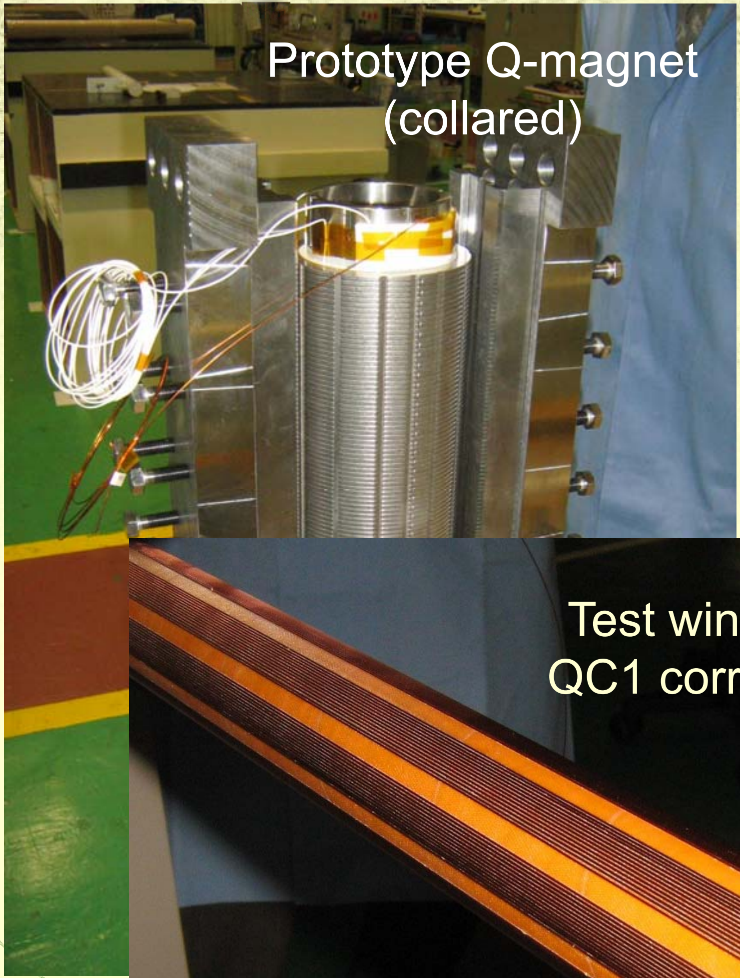
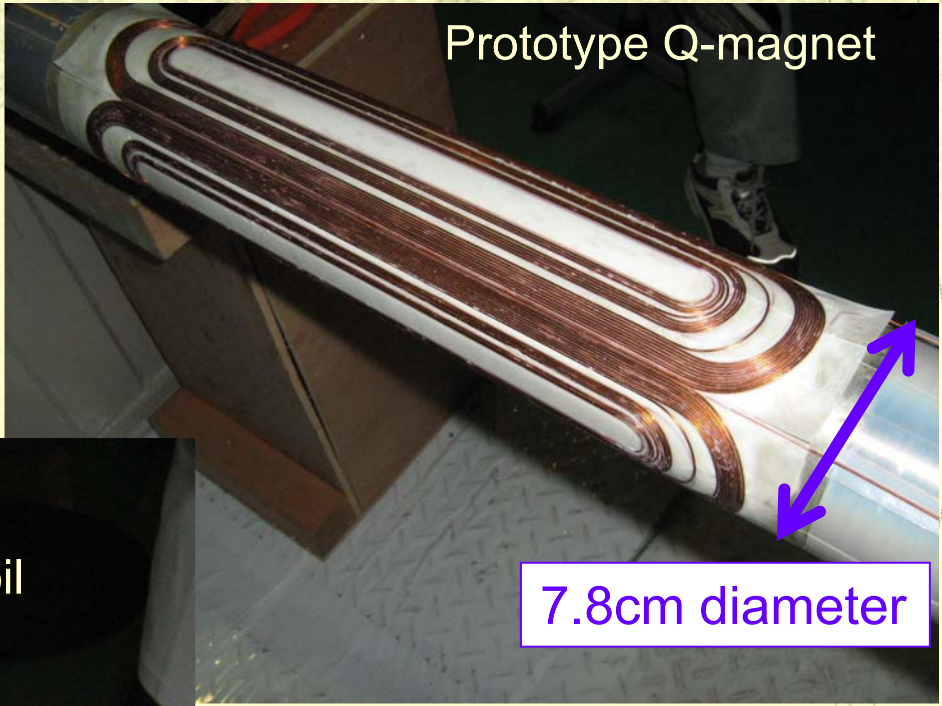




Superconducting Magnet R&D

N.Ohuchi



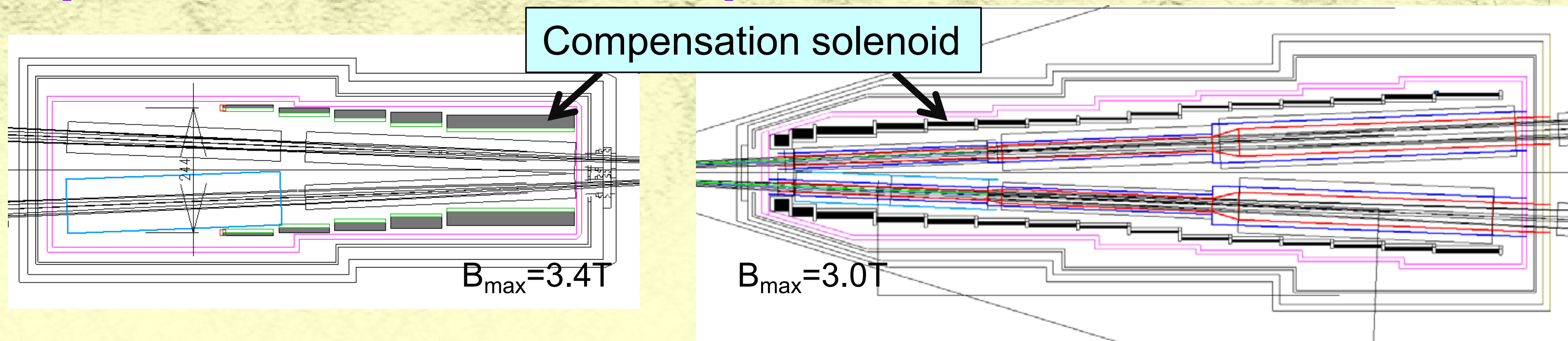


Very compact superconducting magnets for final focusing system

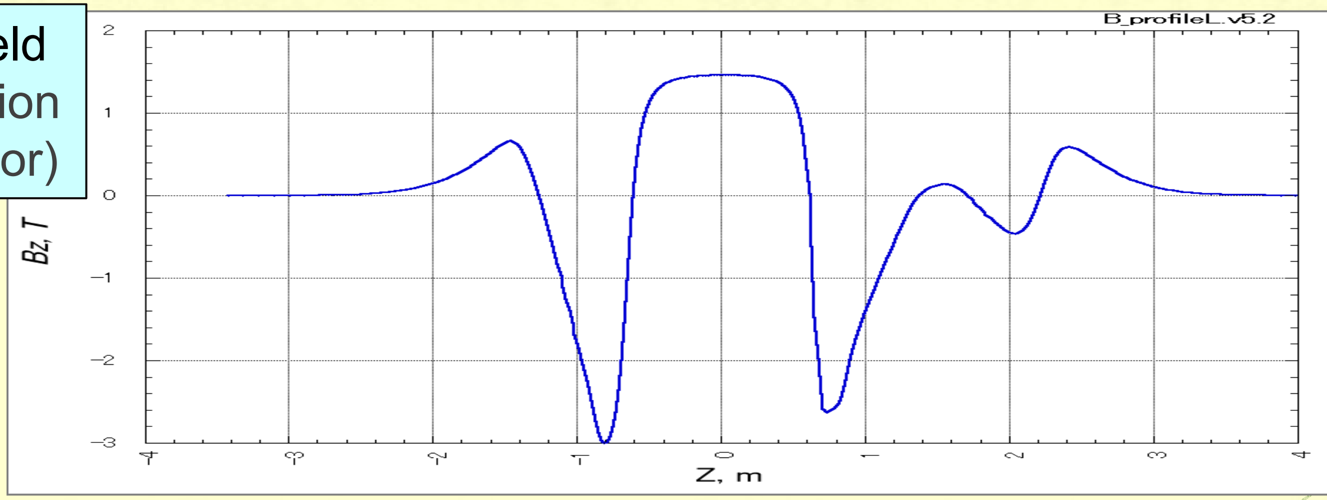
New IR design based on the Nano-beam scheme

Optimization of the compensation solenoid

N. Ohuchi



Solenoid field (compensation + detector)



Fringe fields by compensation solenoid increase the vertical emittance

To solve this → The field change must be as smooth as possible

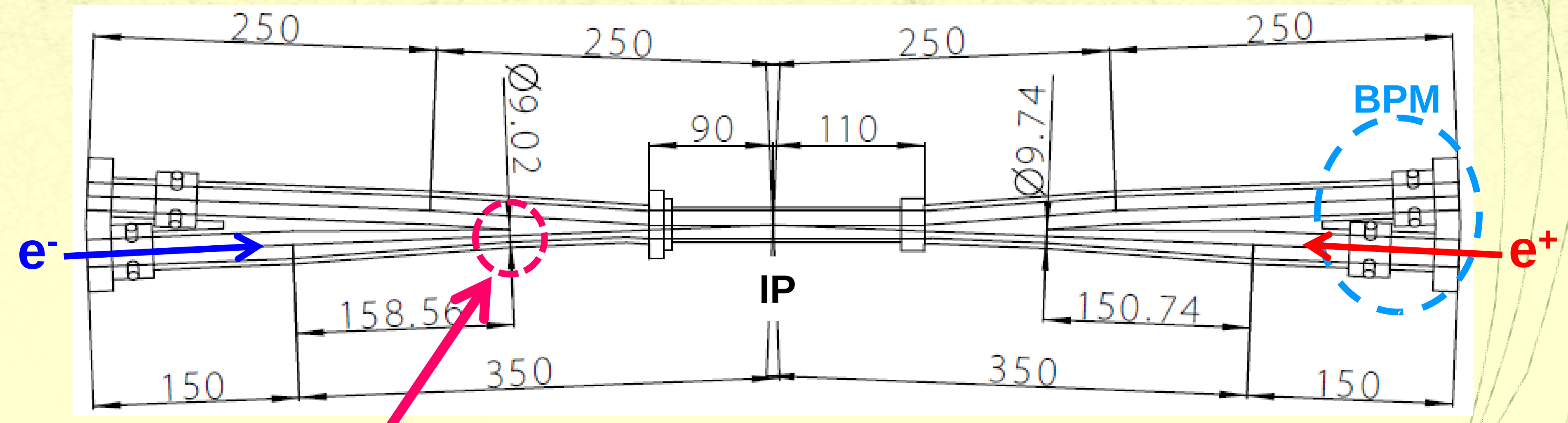
Solenoid field must be canceled within the IR region

New IR design based on the Nano-beam scheme

The new IP beam pipe design

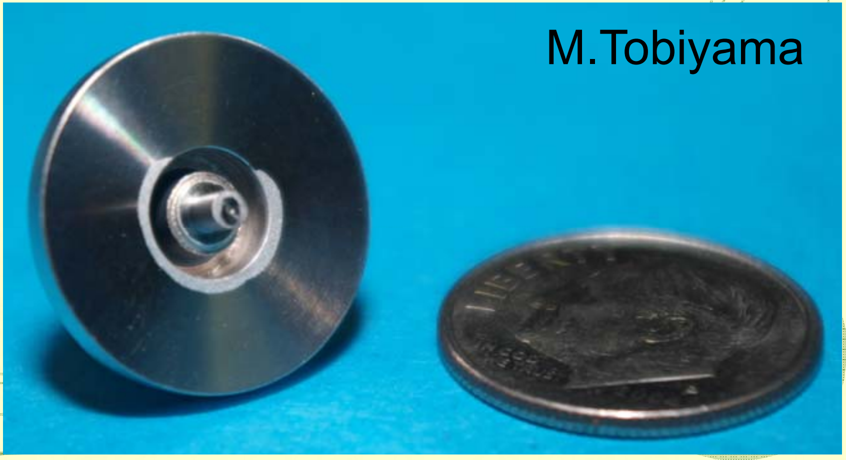
- **Crotched structures** (Two FF Q-magnets in both sides)
- **1cm radius** to avoid the resonant cavity structure

K.Kanazawa



- **4.5mm radius part** to collimate SR from FF Q-magnets

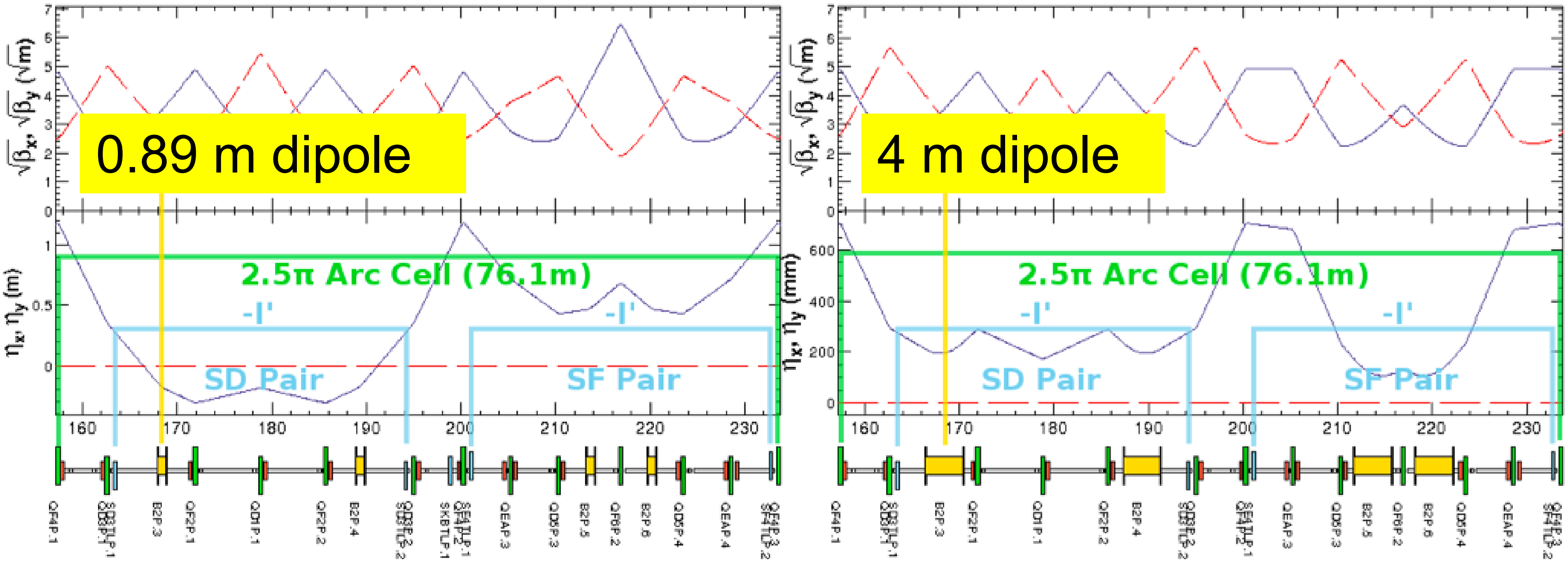
- **Beam Position Monitors** are on the IP beam pipe



New low emittance lattice design

Achieving low emittance with minimum change

Replace short dipoles with longer ones for LER



KEKB LER | SuperKEKB LER

~100 dipole magnets in the arc sections are replaced from 0.89 to 4 m dipoles.

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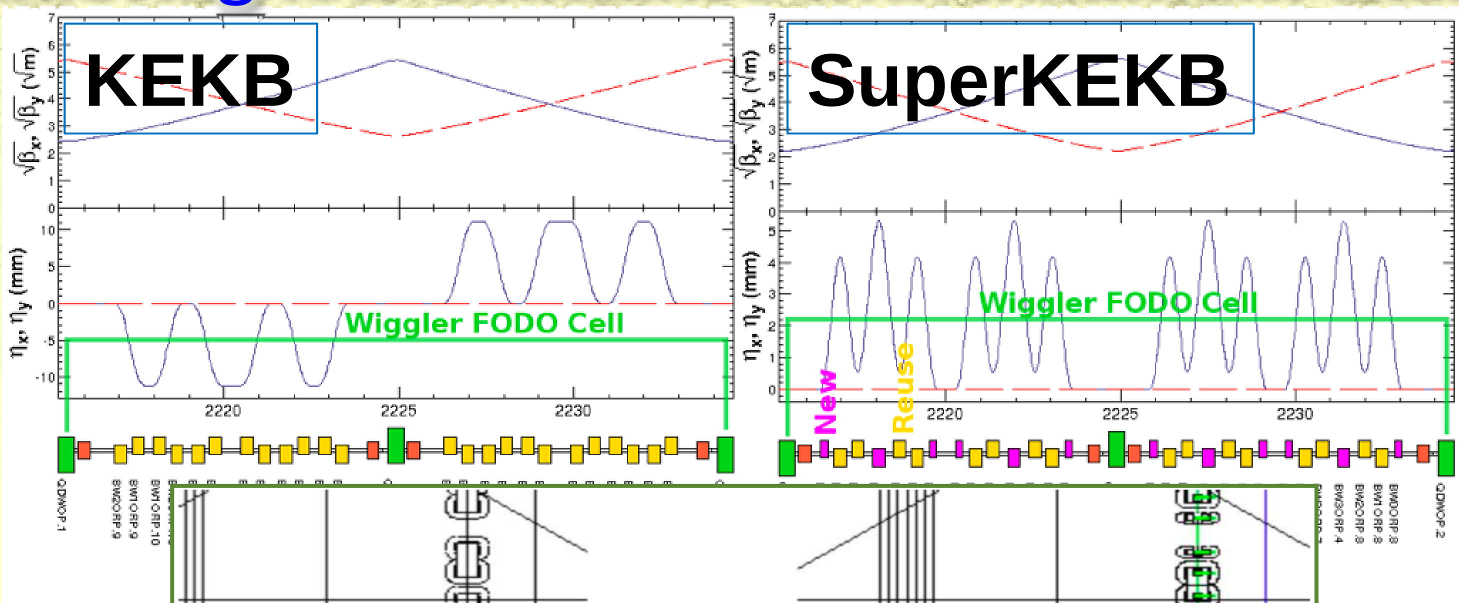
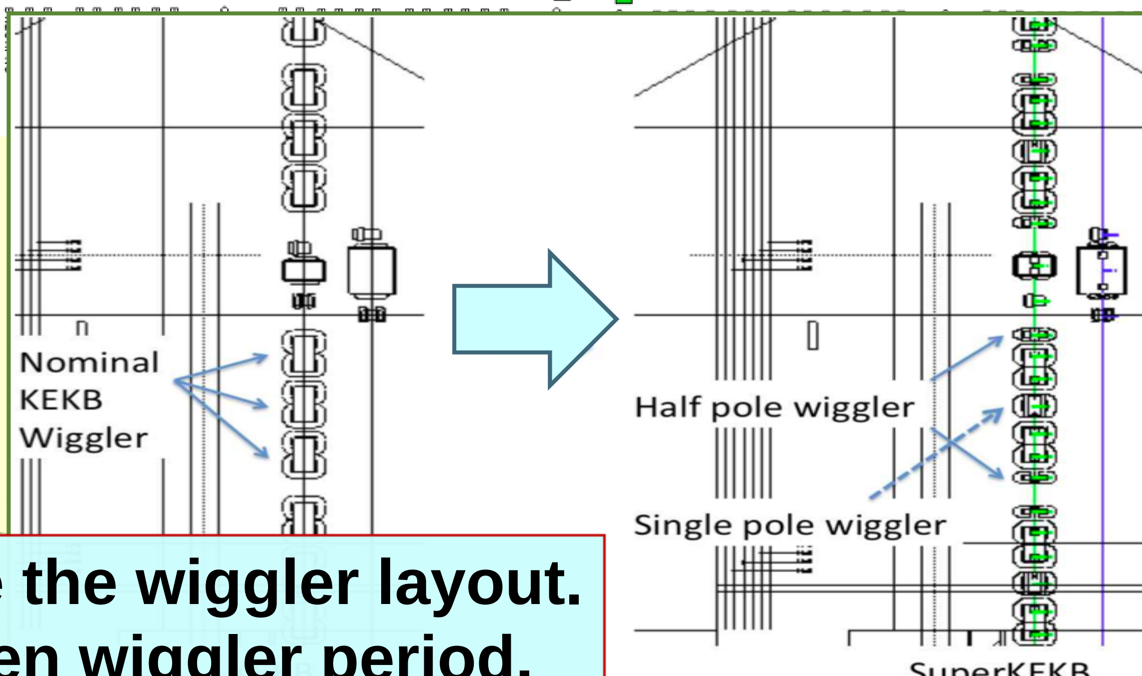
New low emittance lattice design

Achieving low emittance with minimum change





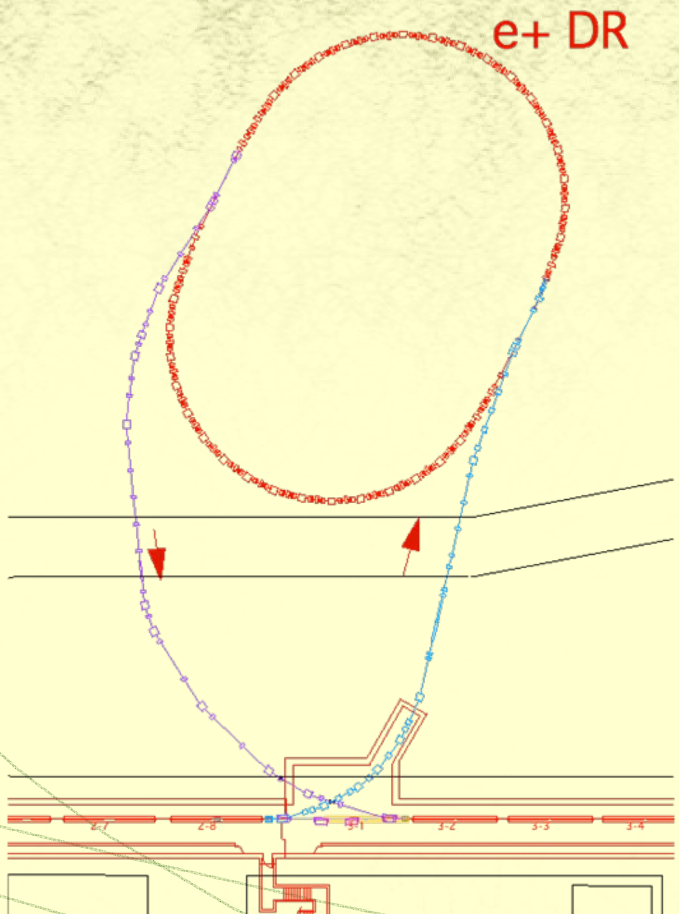
Change the wiggler layout.
Shorten wiggler period.

BELLE-II TDR

New Positron Damping Ring

We construct a positron damping ring for the very low emittance beam injection

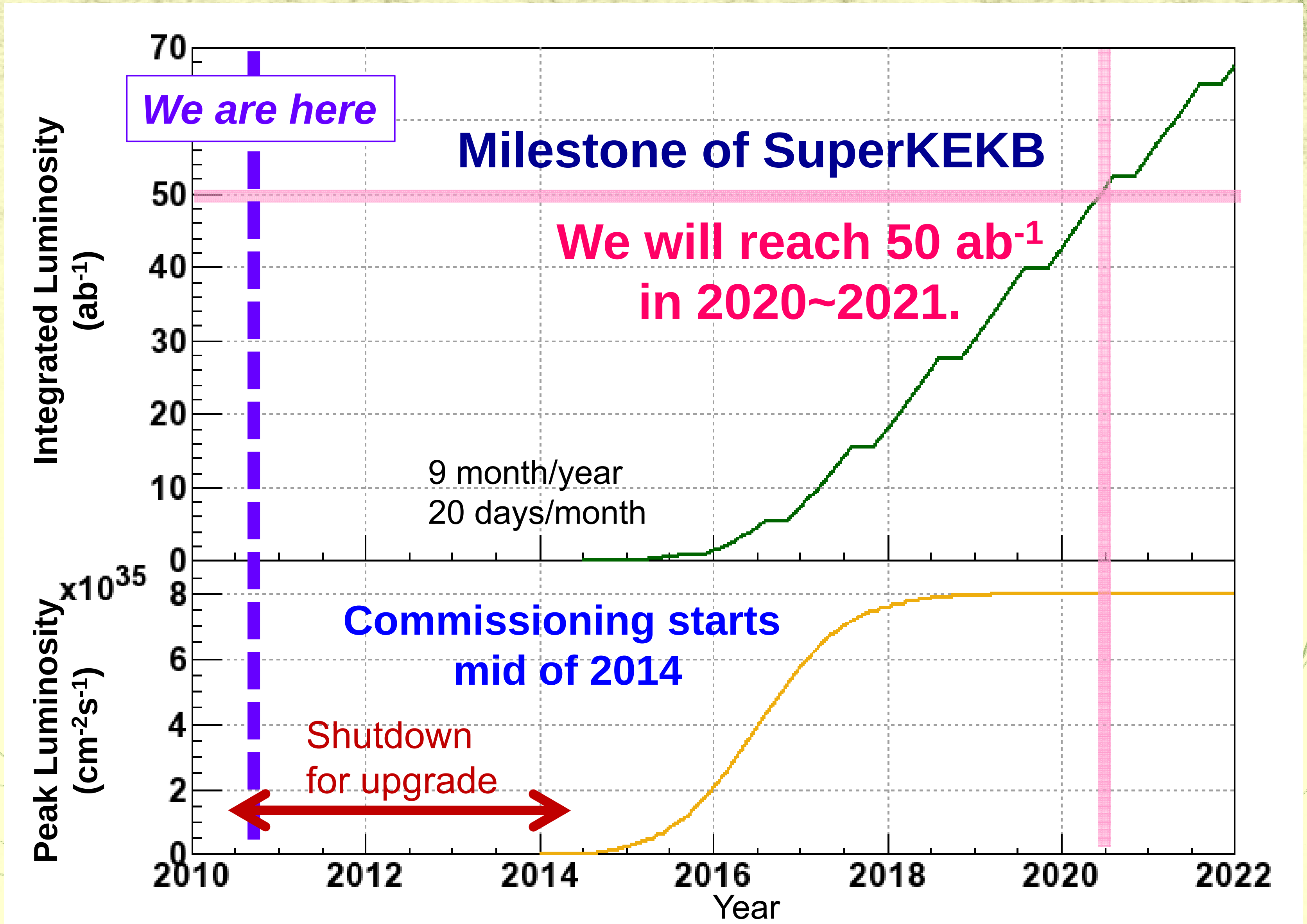
M.Kikuchi



Beam energy (GeV)	1.1		
Circumference (m)	135		
# of train	2		
# of bunches/train	2		
Maximum stored current (mA)	70.8		
Horizontal damping time (ms)	11		
Injected-beam emittance (μm)	1.7		
Emittance @ extraction (H/V) (nm)	42.5 / 2.07		
Cavity voltage (Vc) (MV)	0.5	1.0	1.4
Bunch length (mm)	11.1	7.7	6.5
Momentum compaction (α)	0.0141		
Energy spread (%)	0.055		

Electron cloud will be mitigated by TiN coating and solenoid windings.
Founded for some components such as magnets.

SuperKEKB luminosity upgrade projection



Y. Ohnishi

Summary

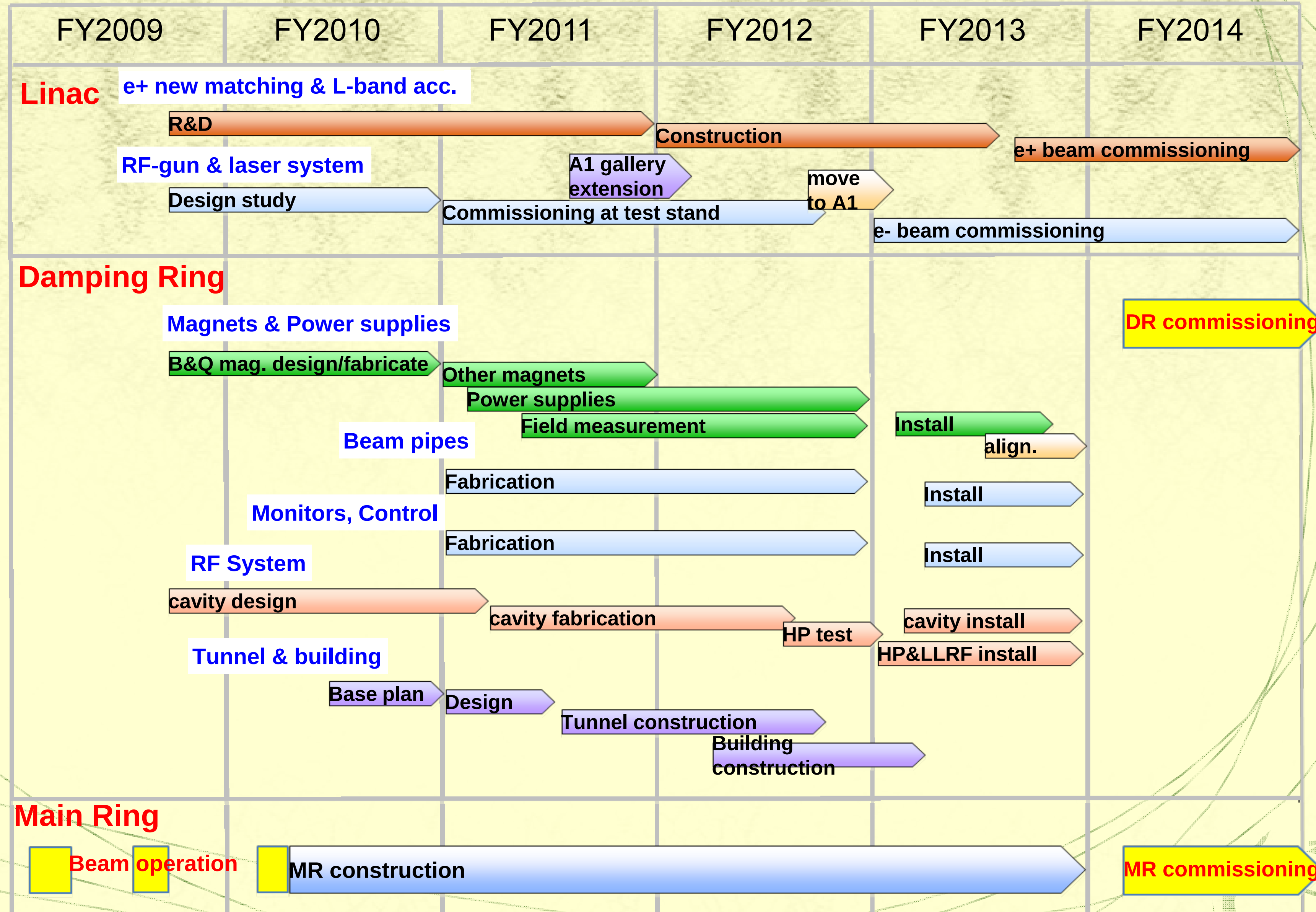
- **KEKB will be upgraded to SuperKEKB**
    - x40 higher peak luminosity ($8 \times 10^{35} cm^{-2} s^{-1}$)
    - x50 integrated luminosity($50\ ab^{-1}$) within several years operation
- **SuperKEKB budget is partially approved**
- **Start the SuperKEKB construction**

    →Plan to start the operation within FY2014

Please also see "Status and Prospects of SuperKEKB and Belle II"
(Y.Ushiroda, 17:15 today @Salle 242A)

Injector upgrade and DR construction schedule

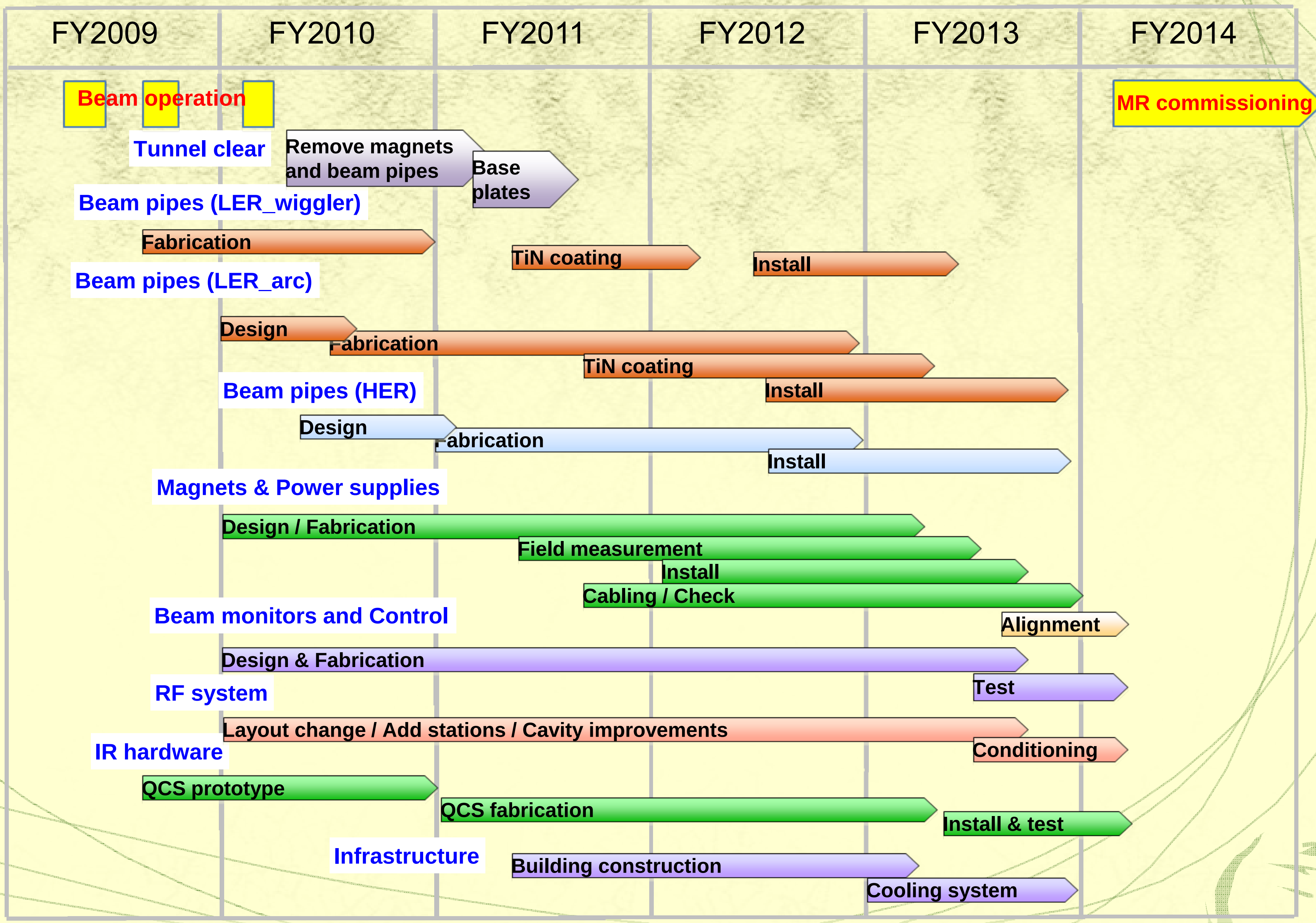
Jun. 24. 2010



K. Akai

SuperKEKB Main Ring schedule

Jun. 24, 2010



K. Akai

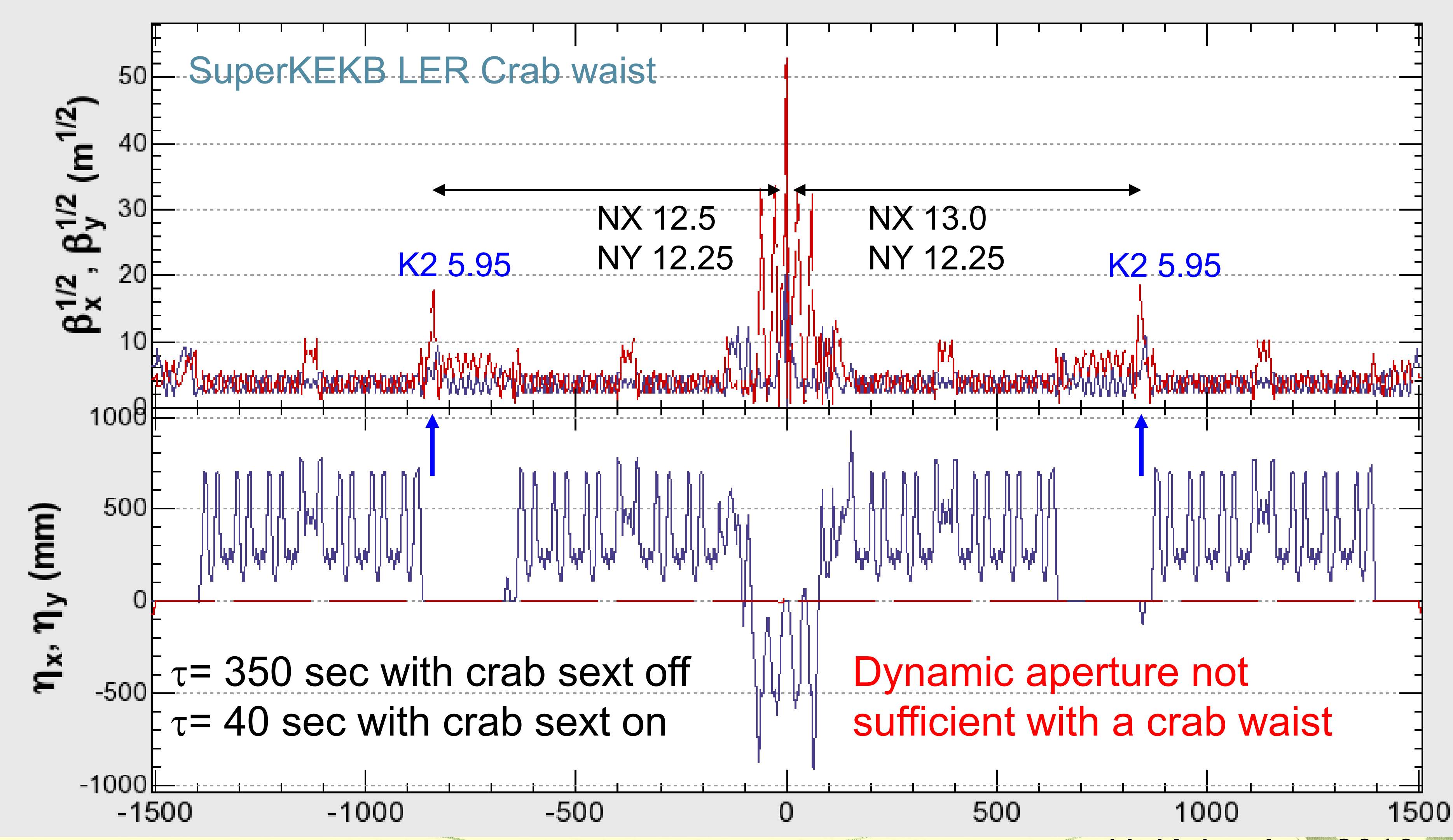
Cost estimation

1 (Oku-Yen) = 1.1 M USD = 0.89 M EUR (as of 18 June, 2010)

Components	Cost (Oku-Yen)	Remarks
Linac upgrade and Damping Ring	45	RF electron gun, positron capture section and L-band acc., Damping Ring components, cooling system
Vacuum System	111	beam pipes (ante-chambers, electrodes, etc), pumps and other vacuum components, cooling system
Magnet System	71	magnets, power supplies, cables, cooling system
IR upgrade	14	QCS and other IR hardware
RF System	24	reinforcement of RF stations, improve cavities and rearrangement
Beam monitor and control	31	BPM, SRM, feedback, control system, etc.
Belle upgrade	19	+ in-kind contribution from other institutions
DR tunnel and buildings	24	DR tunnel, buildings for DR and MR
Total	339	

K. Akai

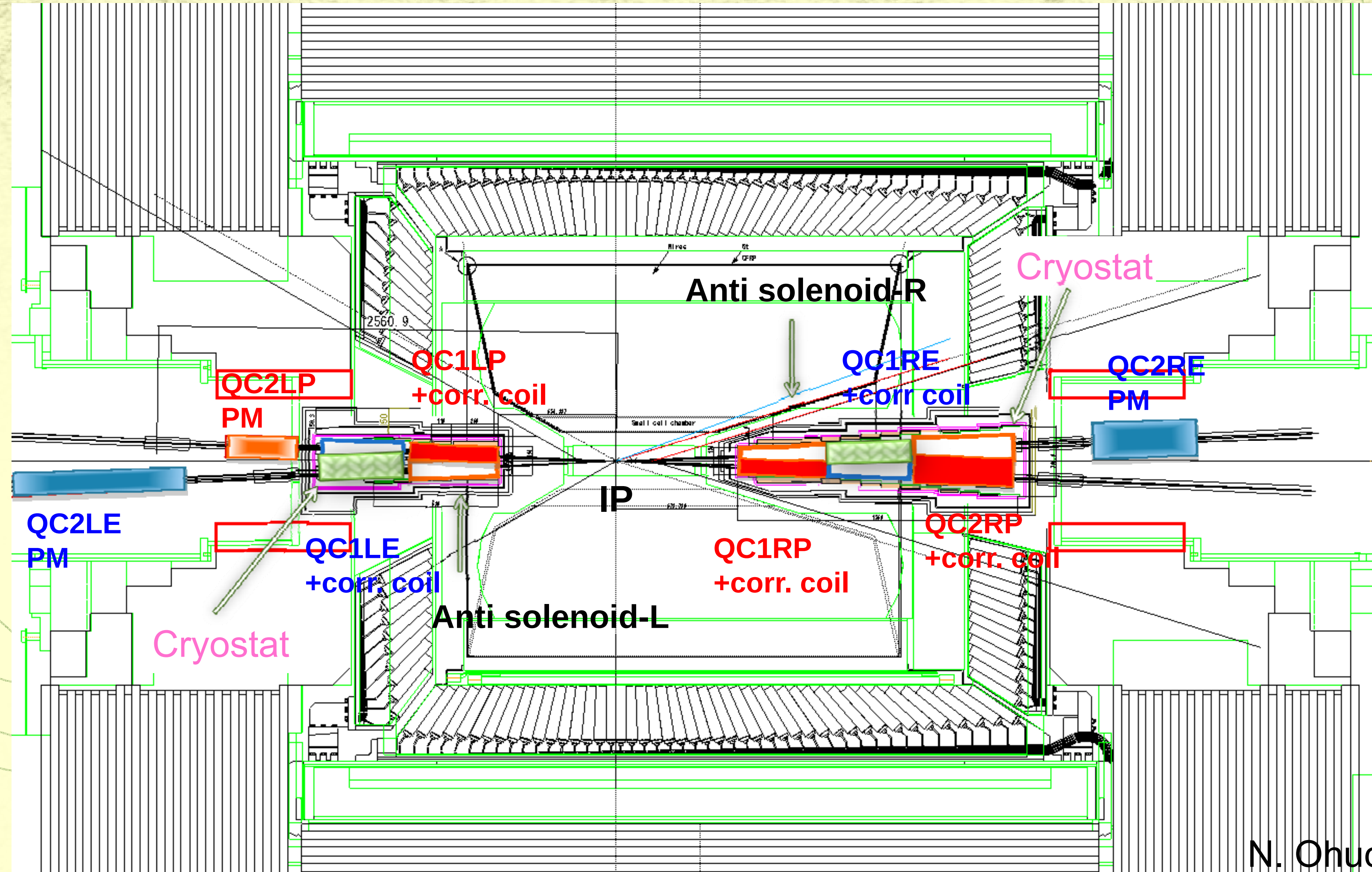
Crab waist scheme for SuperKEKB



H. Koiso Apr. 2010

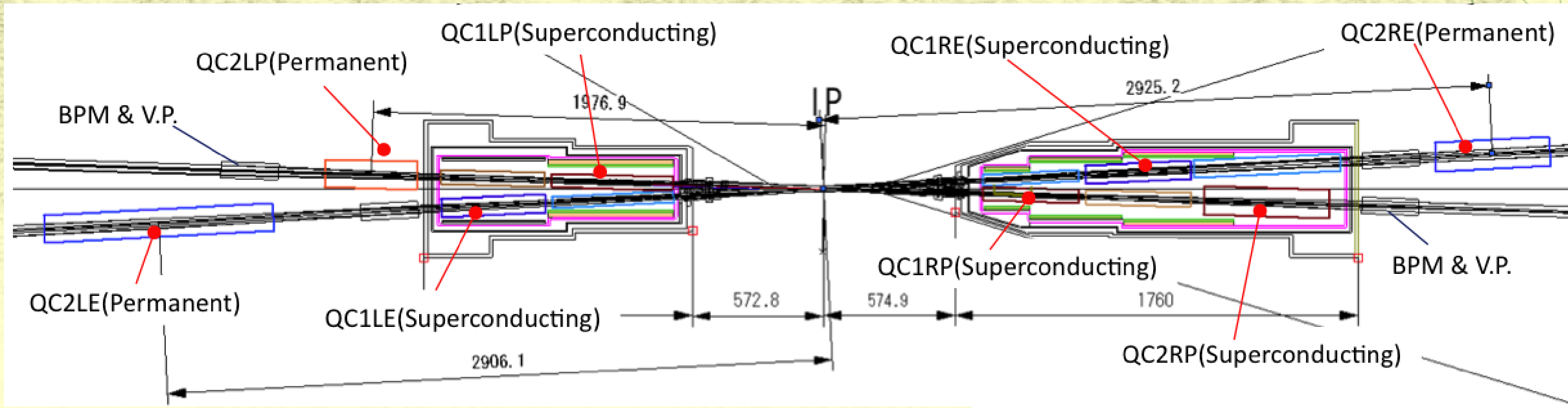
New IR design based on the Nano-beam scheme

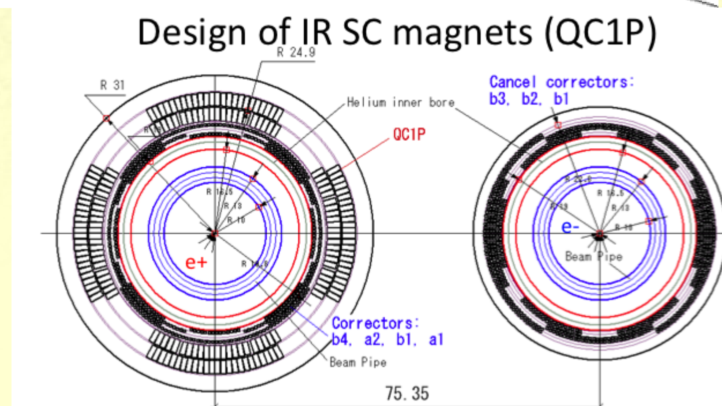
New Final-Focusing system



N. Ohuchi

IR design





Superconducting magnets

- Leakage fields of superconducting magnets are canceled by correction windings on the other beam pipe
- Warm bore

Permanent magnets

- Cryostats can be made smaller
- Assembly of vacuum chamber can be simpler
- Vacuum pumps can be located nearer IP
- R&D work needed for developing permanent magnets
- Temperature dependence
- Tunability (an additional magnet is needed when changing the energy)

BELLE-II TDR N.Ohuchi, M.Tawada