KEKB ACCELERATOR REVIEW COMMITTEE
FEB 22 2005

IR Overview

Y. Funakoshi (KEK)

Choice of machine parameters

Design parameters of KEKB and SuperKEKB

	KEKB (design)		SuperKEKB	
	LER	HER	LER	HER
I [A]	2.6	1.1	9.4	4.1
β_y^*[mm]	10	10	3	3
ξ_y	0.052	0.052	0.14	0.14
L [/cm^2/sec]	1 x 10^{34}		2.5 x 10^{35}	
σ_l [mm]	5	5	3	3

IR basic parameters

	KEKB (design)		SuperKEKB	
	LER	HER	LER	HER
β_y^*[mm]	10	10	3	3
β_x^*[cm]	33	33	20	20
ε_x [nm]	18	18	24	24
ϕ [mrad]	11		15	

β_y^* : basic assumption of SuperKEKB design

β_x^*, ε_x : from beam-beam simulations

ϕ : assumption for IR design

Crossing angle (ϕ)

	±11mrad	± 15mrad
Physical aperture of IR magnets	No solution	tight
Power of SR from QCS magnets	lower	higher
Required voltage of crab cavities	lower	higher
Parasitic collision effects	Not yet studied	Talk by Tawada

Issues

Issues of IR Design

Issues	Causes	Measures
Dynamic aperture	Lower beta's at IP.	Place QCS magnets. closer to IP. Damping ring.
Physical aperture	Lower beta's at IP. Energy switch.	Damping ring. Larger crossing angle.
Heating and mechanical breakdown of IR components	Higher beam currents. Higher power of SR from QCS magnets. Shorter bunch length (HOM).	Under study.
Detector beam background	Higher power and critical energy of SR from QCS magnets. Higher beam currents. QCS closer to the IP. Higher ξ_y and shorter bunch length.	Under study by Belle Group.

Design Work Overview

IR Design Works

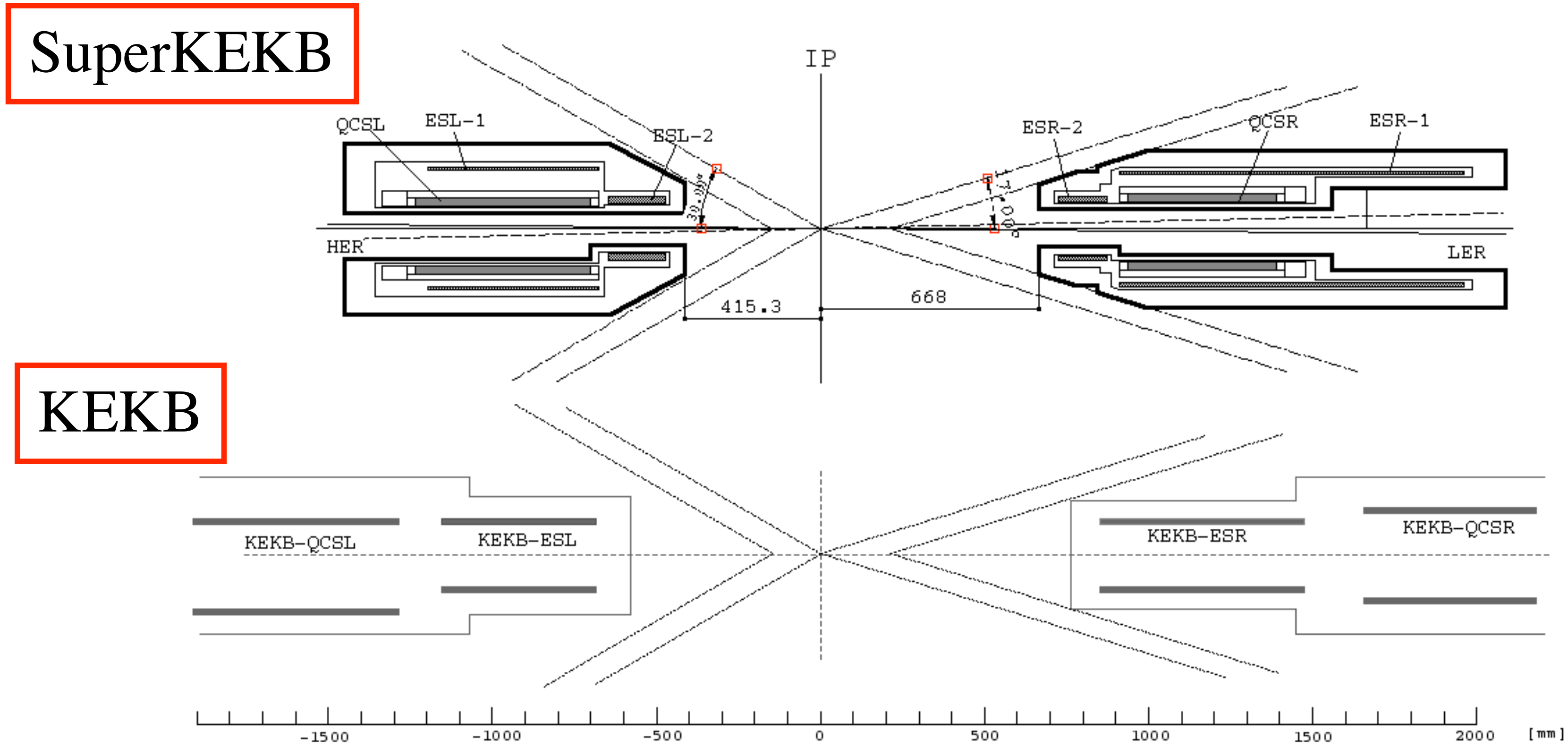
- We have to concurrently pursue the following design works until we find a consistent set of solutions.
  - **Choice of machine parameters**
  - **Beam-beam simulations (Talk by Tawada)**
  - **IR Magnet design (Talks by Ohuchi)**
  - **Optics and dynamic aperture (Talk by Ohnishi)**
  - **IR Vacuum design (Talk by Kanazawa)**
  - **Detector beam background (Talk by Tajima)**

QCS Magnets Design (Ohuchi)

- Design principles
  - **Move QCS's closer to the IP.**
  - **Higher field gradient.**
  - **Detector solenoid field is cancelled in each side of the IP.**

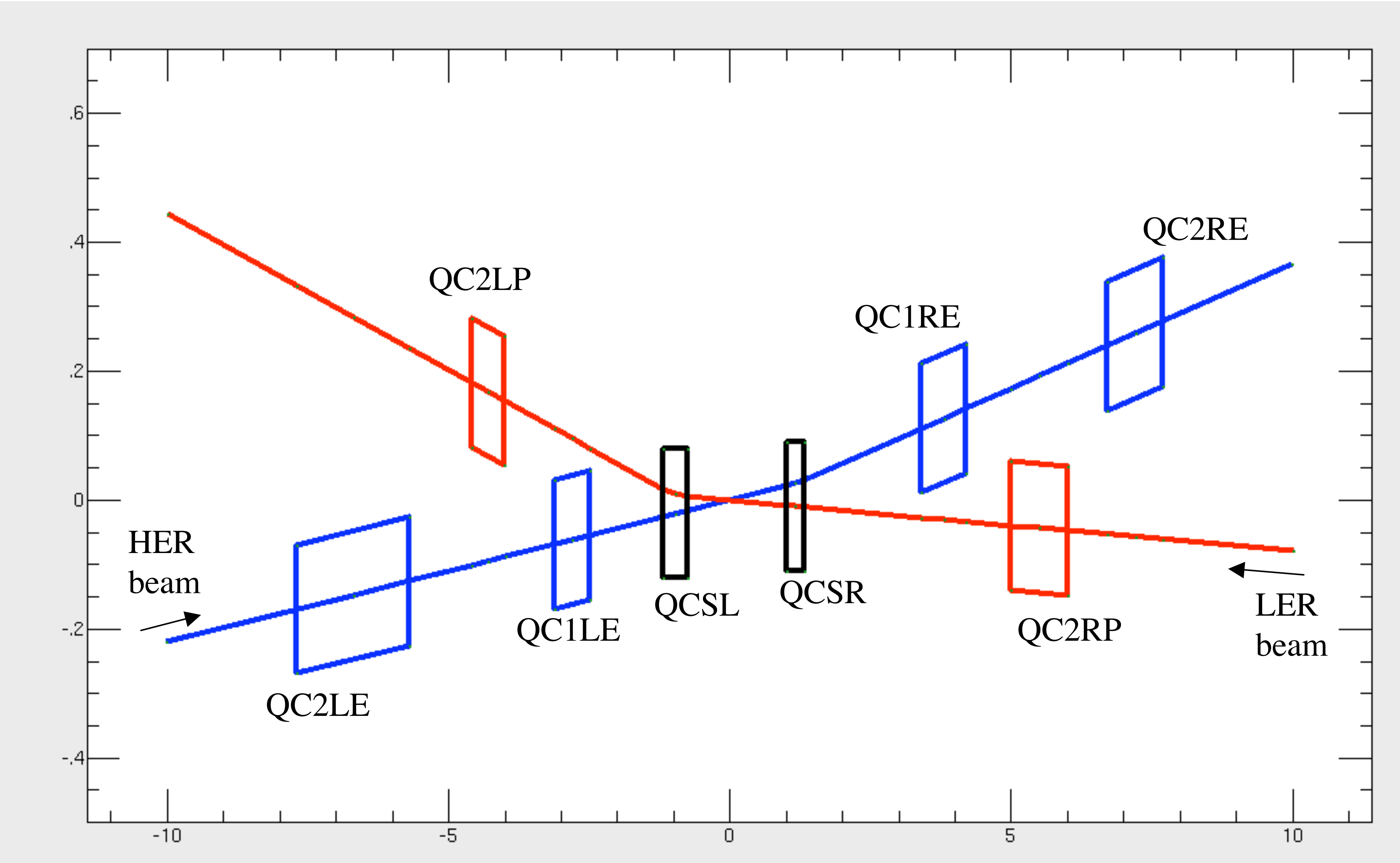
Parameters	SuperKEKB	KEKB	Units
Distance from IP to QCSL	0.969	1.60	m
Distance from IP to QCSR	1.163	1.92	m
Effective length of QCSL	0.3982	0.483	m
Effective length of QCSR	0.333	0.385	m
Field Gradient of QCSL	35.4	21.66	T/m
Field Gradient of QCSR	37.2	21.73	T/m

Place QCS magnets closer to IP



The boundary between KEKB and Belle is the same as that of present KEKB.
ESL and ESR will be divided into two parts (to reduce E.M. force).
QCSL (QCSR) will be overlaid with (the one part of) ESL(ESR).

IR magnet layout



Required information for further IR magnet designs

- Required ring acceptance
  - Determined by the beam injection requirement.
  - Every magnet should keep the required acceptance.
  - Required ring acceptance is also needed from the viewpoints of estimation of dynamic aperture.
- Fan of SR from the QCS magnets
  - Every IR magnet should be designed to avoid irradiation by the SR.
  - SR fan is also needed for the vacuum chamber design and the estimation of the detector background.

Required Ring Acceptance

	LER	HER
e-/e+	e-	e+
Energy [GeV]	3.5	8.0
Damping Ring	No	Yes
A_x [μm]	2.6	1.5
A_y [μm]	0.18	0.025

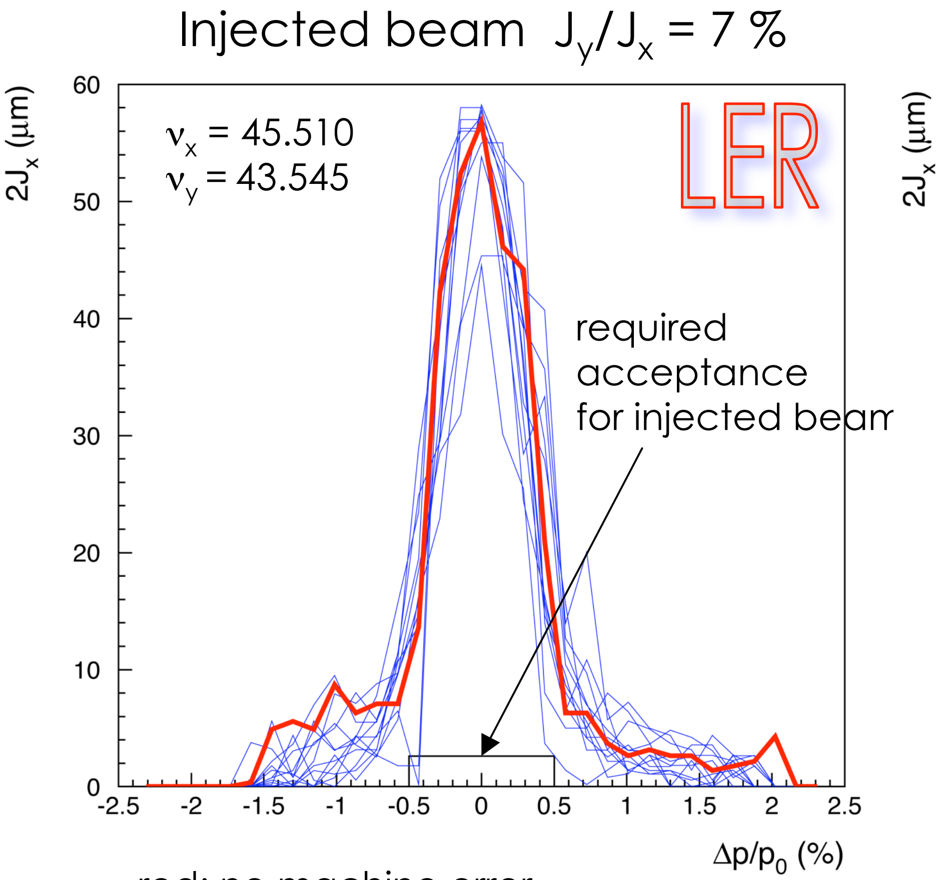
Energy switch is assumed from the beginning of SuperKEKB operation.
A damping ring will be needed for the e+ beam.

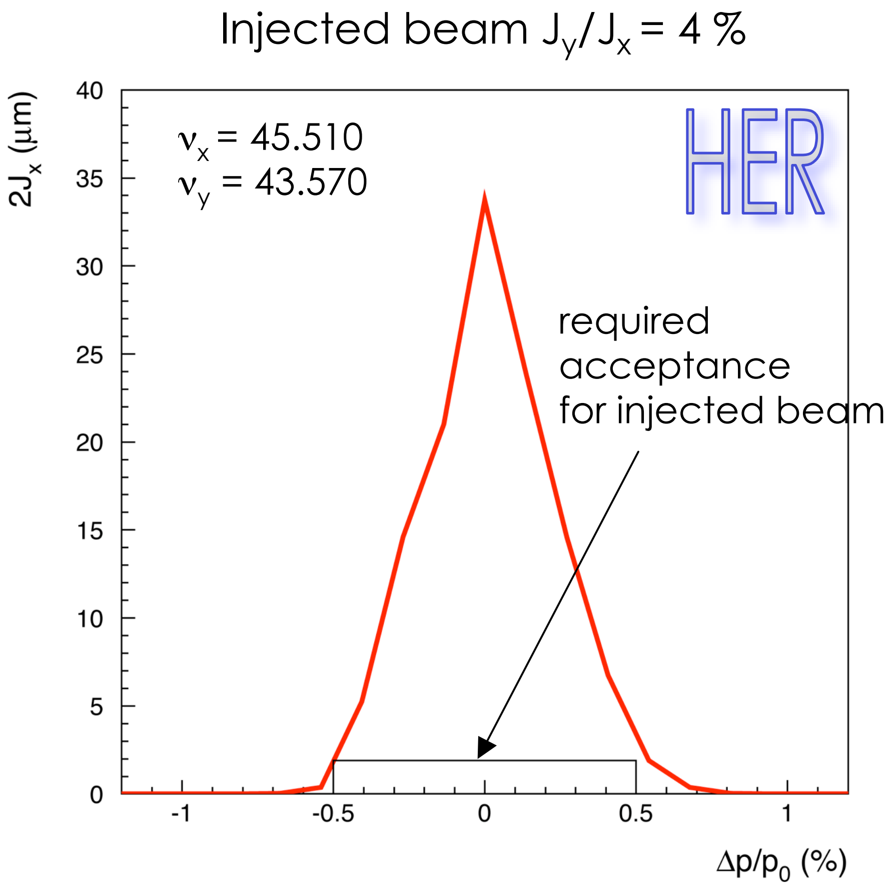
SuperKEKB Construction Schedule (2005.1.18)

Fiscal Year		2006	2007	2008	2009	2010	2011		2012
Budget				SuperKEKB Main Budget					
KEKB Ring		KEKB Operation			Shutdown			SuperKEKB	
Damping Ring				Construction	Installation	Commissioning		Operation	
Linac Upgrade								e+ 8GeV	
	# of Units	2	2	2	14	14	14		
RF Upgrade									
	D1							2 (Crabs)	→
	D2							2 (Crabs)	→
	D4	3 (6A)	→	→	→	→	→	14(14AH)	→
	D5	3 (6A)	4 (6A)	→	→	→	→	10(2H+8L)	→
	D7	5 (10A)	→	→	→	→	→	10 (10AL)	→
	D8	5 (10A)	→	→	→	→	→	10 (10AL)	→
	D10	4 (4S)	→	→	→	→	→	6(6SH)	→
	D11	4 (4S)	→	→	→	→	→	6(6SH)	→
	DR					1(1A)	→		→
	Klystron fab.	5	6	7	7	6	5		0
Infrastructure									
	Bulding		Construction						
	Electricity			Construction					
	cooling water			Construction					
Vacuum Upgrade				Construction, Installation					

Dynamic Aperture for Injected Beam

Ohnishi



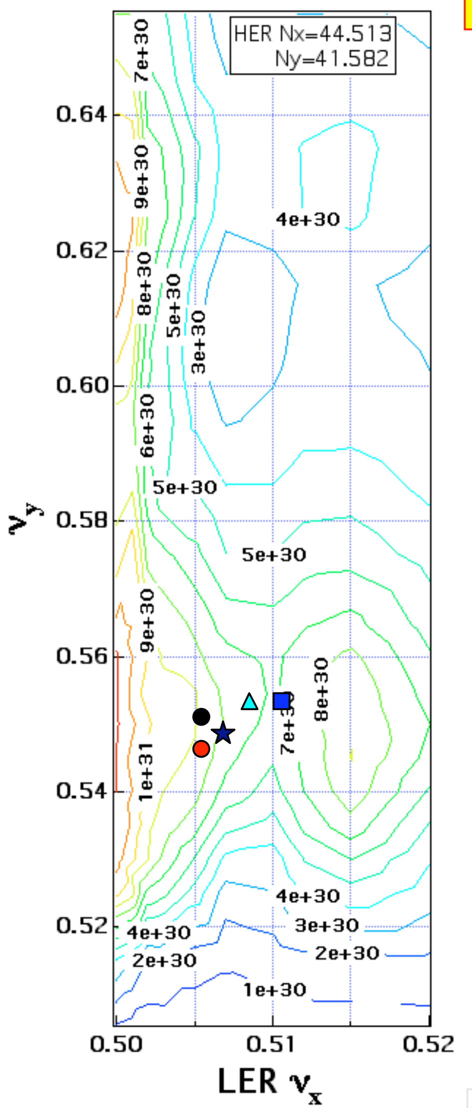


red: no machine error
blue: machine error + optics correction
(12 lines indicate different seed numbers.)

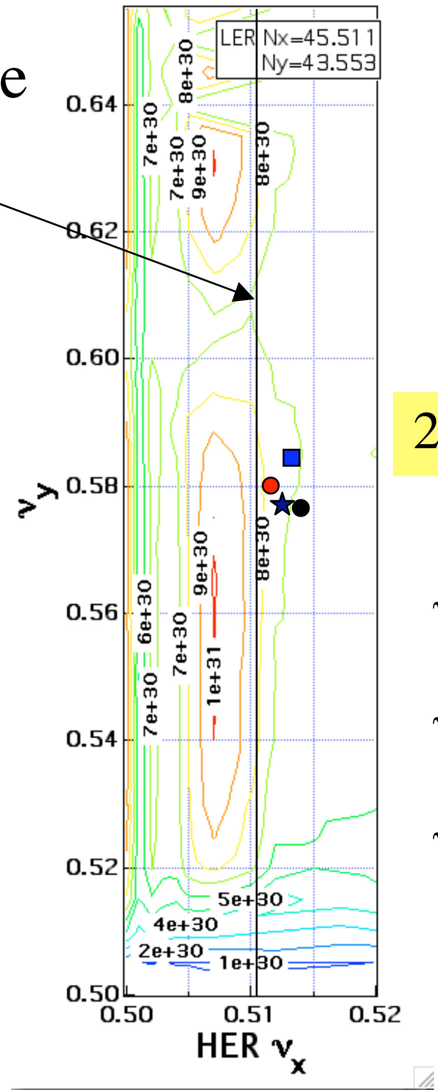
Estimated dynamic aperture of HER is marginal. Do we need a local chromaticity correction also In HER?

Synchro-betatron Resonance

Another reason of need for HER Local correction



Resonance line



10/29/2002

4/2/2003

5/9/2003

12/18/2003

1/21/2004

ν_s = -0.0249@8MV

$2\nu_H + \nu_s$ = integer

ν_s = -0.0209@13MV (May 09 2003)

ν_s = -0.0225@15MV (Dec 18 2003)

ν_s = -0.0217@14MV (Jan 21 2004)

Beam-Beam simulation (Tawada)

Problem

- HER local chromaticity correction scheme is not compatible with installation of crab cavities in Tsukuba section.
- If we want to install crab cavities in Tsukuba, we can not adopt the local correction scheme in HER.
- We need to wait for the results of the experiment with the crab cavities in Nikko section next year.

Fan of SR

- Consideration of the particle distribution in the phase space
- Effects of dynamic-β and dynamic-emittance
  - **These effects are very large with the horizontal tune very close to the half integer.**
- We took $9\varepsilon_x$ ($3\ \sigma_x$, $3\sigma_{x'}$) into consideration.

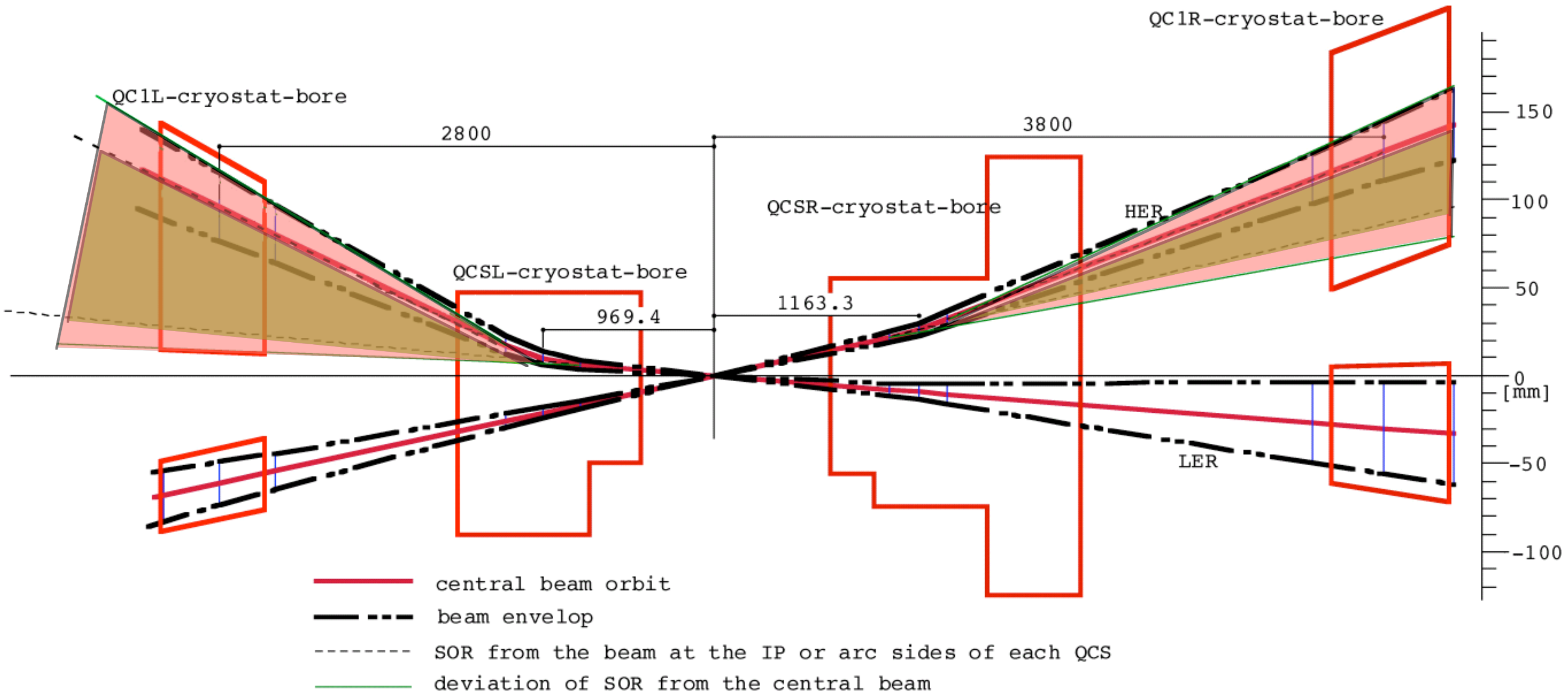
Enlargement of SR fan due to dynamic effects

	without dynamic effects		with dynamic effects	
Source point	QCSRE(Arc side) HER	QCSLE(Arc side) LER	QCSRE(Arc side) HER	QCSLE(Arc side) LER
Observation point	Exit of QC1RE	Exit of QC1LE	Exit of QC1RE	Exit of QC1LE
ε_x[nm]	24		58	
γ_x^* $(1/\beta_x^*)$ [/m]	5		22.5	
Distance from a source point [m]	2.87	1.94	2.87	1.94
Δx[mm] COD	5.2	5.5	5.2	5.5
Δx[mm] 3 σ_x, 3$\sigma_{x'}$	5.1	5.4	17.7	18.3
Δx[mm] Total	10.3	10.9	22.9	23.8

$\xi_x = 0.1,\ \nu_x = .510$

Fan of SR

Ohuchi



Power of SR from QCS Magnets

	QCSR	QCSL
Magnet length [m]	0.33	0.42
Δx [mm]	34.5	29.1
G [T/m]	37.2	35.4
B [T]	1.28	1.03
E_b [GeV]	8.0	3.5
I [A]	4.1	9.4
P [kW]	179 (27)	64.6 (10)

( ): present KEKB Design

Vacuum system design issues (Kanazawa)

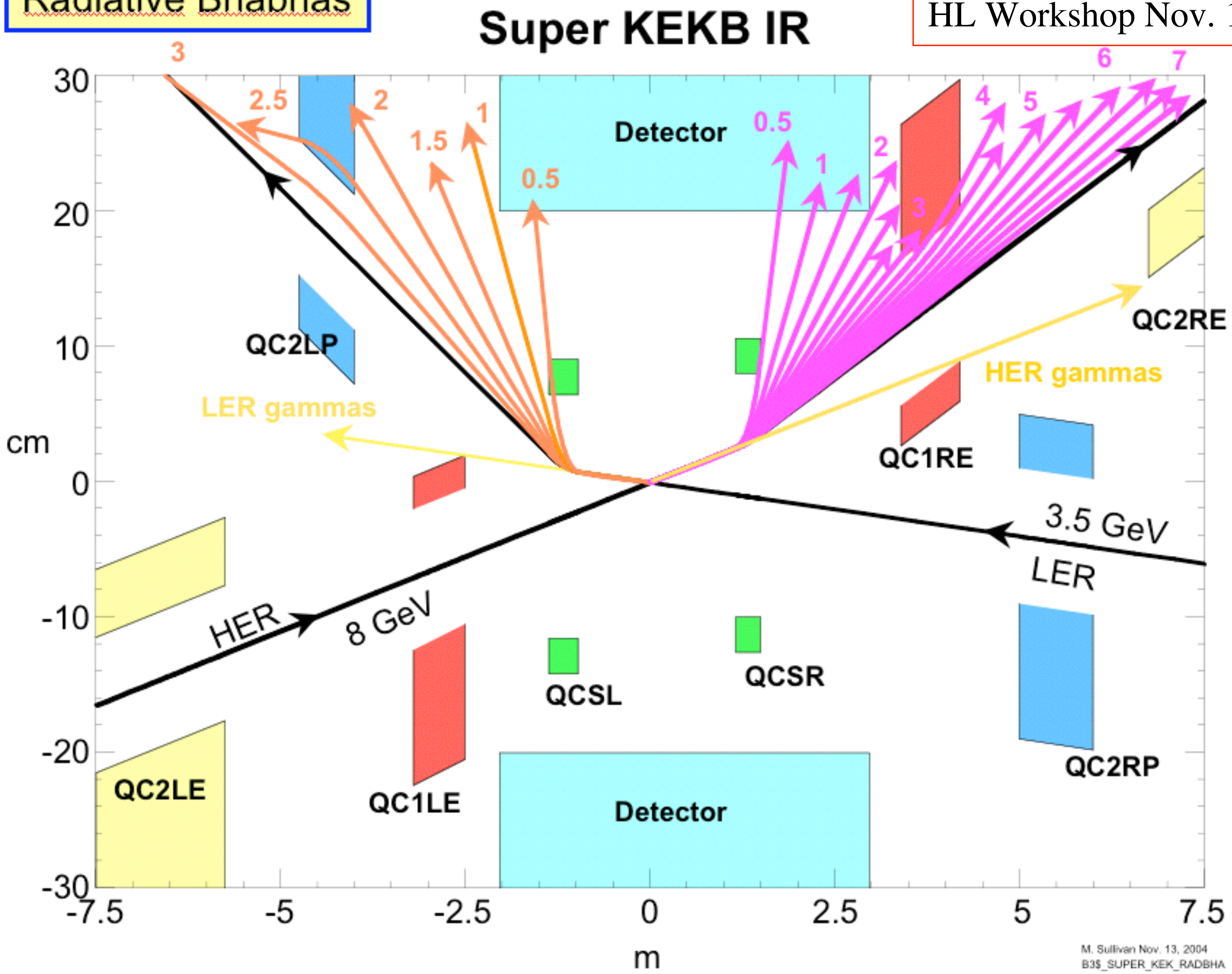
- SR from QCS's
  - **How to handle the high power?**
  - **How to suppress the SR background to Belle?**
- HOM power
  - **A few * (100kW) will be turned into heat in IR (Kanazawa).**
  - **How to deal with its power?**
- More durable vacuum components?
- Denser vacuum pumps from reducing particle beam background?

Detector beam background issues (Tajima)

	Mechanism	Reason of severeness
Particle loss	Radiative Bhabha	High Luminosity, QCS’s closer to IP
	Collision with residual gas	High currents
	Touschek effect	Short bunch length, high ξ_y, smaller dynamic aperture
SR	Emitted at QCS’s	High current, larger ϕ_c, Higher field of QCS’s

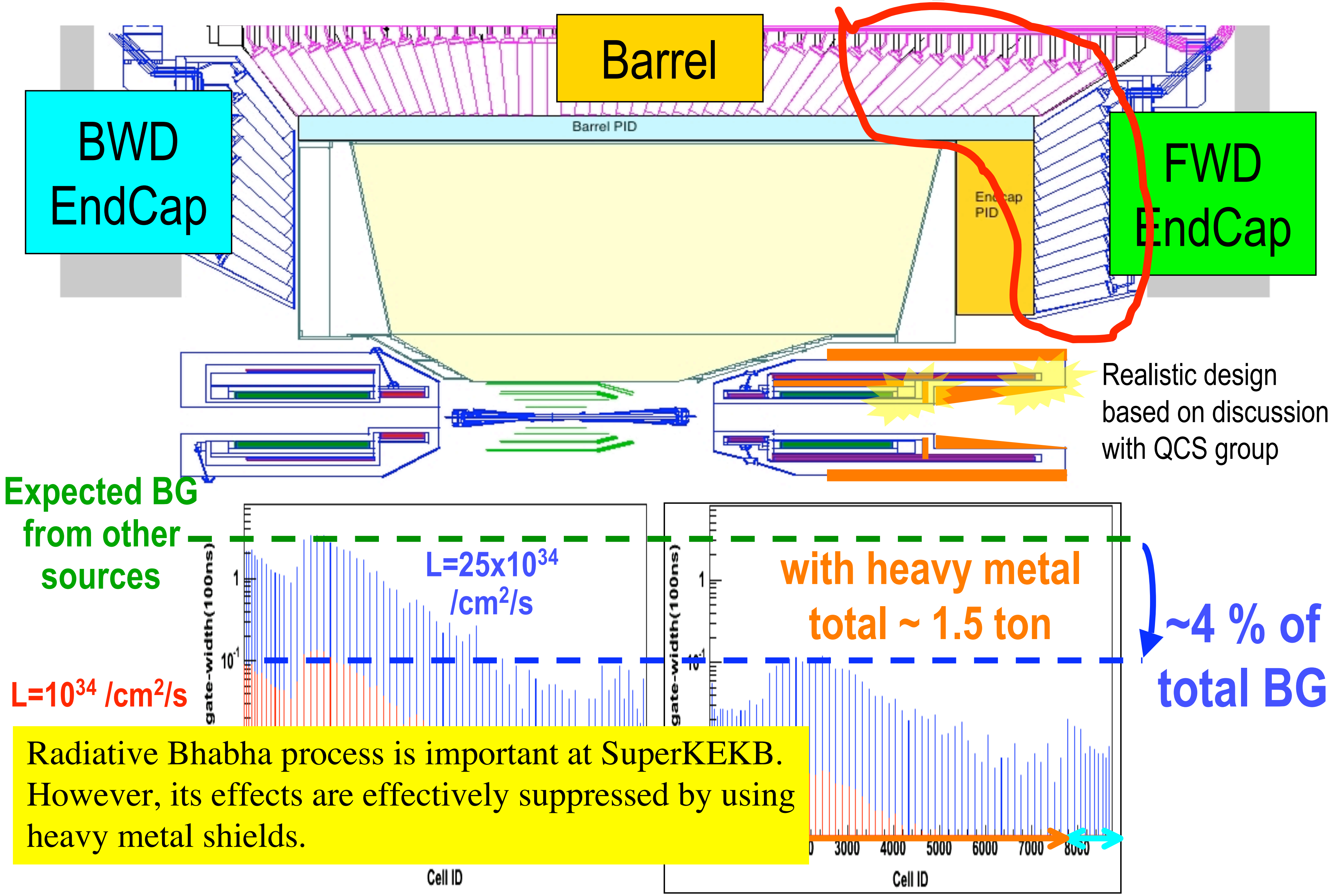
Radiative Bhabhas

M. Sullivan
HL Workshop Nov. 13 2004



Tajima

Rad. Bhabha BG sim. for Super-KEKB



Radiative Bhabha process is important at SuperKEKB. However, its effects are effectively suppressed by using heavy metal shields.

Spare Slides

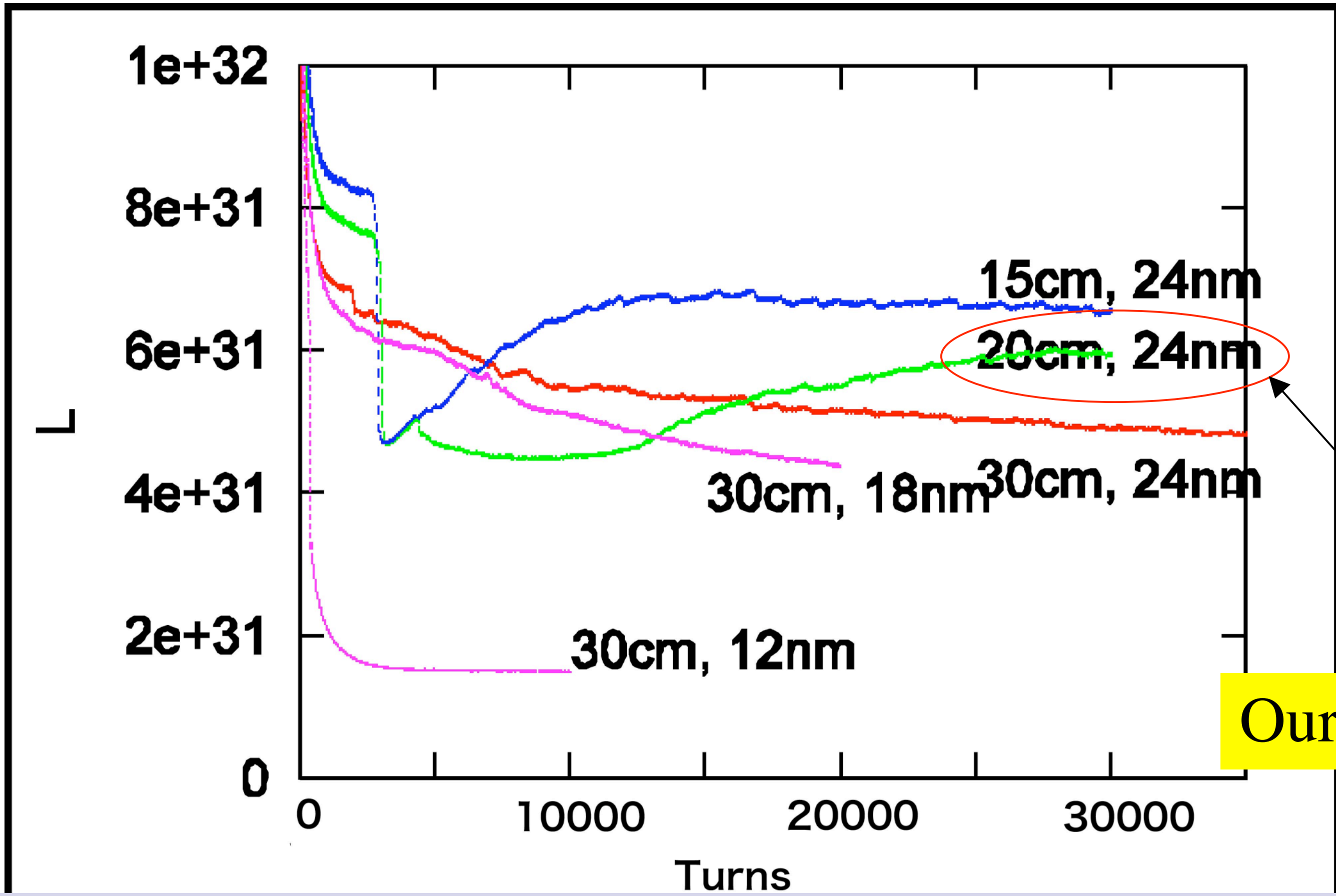
Other works to be done

- Other engineering issue
  - **Mechanical support of the magnets**
  - **Solution of spatial conflicts among components**
- Design of IR special beam monitor system

Choice of β^*_x, ε_x

- β^*_x=30, 20, 15 cm
- ε_x=24, 18, 12 nm

Strong-Strong Beam-Beam Simulations by K. Ohmi



Our choice

Achievable beam-beam parameters depends on β^*_x and ε_x.

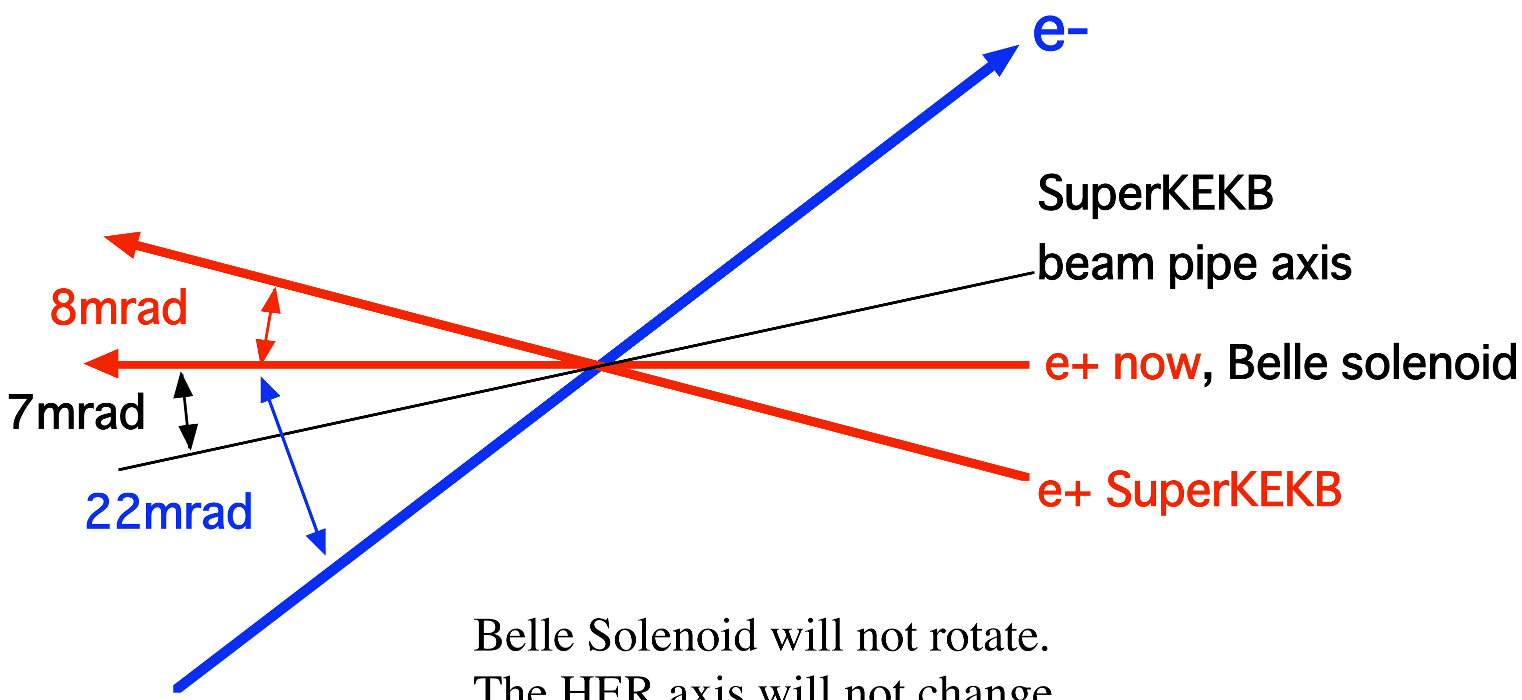
Crossing angle (ϕ)

- QCS (defocusing quadrupole) magnets are placed closer to IP.
- β_x^* is smaller.
  - **The maximum value of β_x around IP becomes very large.**
    - Physical aperture will be an issue particularly in the horizontal direction.
    - To mitigate this problem, the crossing angle will be increased from ±11mrad to ±15mrad.

QC1 magnet design

- Severe physical aperture requirement
- Two options (-> Ohuchi and Tawada’s talk)
  - **Normal quadrupole**
  - **Superconducting**
    - Normal quadrupole has higher priority.
    - The option of superconducting magnets is a backup.

Geometrical Relationship between SuperBelle and SuperKEKB



Belle Solenoid will not rotate.
The HER axis will not change.
The LER axis will rotate by 8mrad.
The beam pipe (and SVD) have a finite angle of 7mrad with respect to Belle Solenoid.
QCS magnets will be set parallel to Belle Solenoid.

Critical energy of SR from QCS magnets

	QCSR	QCSL
Distance from IP to magnet center [mm]	1163.3	969.4
Δx [mm]	34.5	29.1
G [T/m]	37.2	35.4
E_b [GeV]	8.0	3.5
u_c [keV]	54.7(37.4)	8.40(5.95)

( ): present KEKB