IR Optics

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Tow Options

- High current, crab crossing, large beambeam parameter.
 - A solution for $\beta^* x = 20 \rightarrow 40$ cm
- Low emittance, low β^* , nano-beam.
 - Just started.
 - Crossing angle $30 \rightarrow 60$ mrad

High Current Option

SuperKEKB machine parameters

SuperKEKB using traveling focus (only for LER) and negative α						
		LER	HER			
F reitten oo	ε _x	24	18	nm		
Efficiance	εγ	0.24	0.09	nm		
Data at ID	β _x *	20	20	cm		
Dela al IP	β _y *	3	6	mm		
Bunch length	σ,	5 3		mm		
Betatron tune	v_x/v_y	.505/.5905 .505/.5905				
Synchrotron tune	ν _s	0.025	0.025			
Beam current	I_+/I	9.4	4.1	А		
#bunches/harmonic#	N _b /h	5018,				
Crossing angle	2φ _x	30 → 0 (cr	mrad			
D ec. b c c v *1	ξ _x	0.182	0.138			
Dediti-Dediti -	ξy	0.295	0.513			
	T _x	6000	4000	turns		
Damping	Ty	6000	4000	turns		
	T _e	3000	2000	turns		
Luminosity	L	5.3x	cm ⁻² s ⁻¹			

K. Ohmi Y. Funakoshi

*1: ignore effects of traveling focus

Large Dynamic Effects

- The beam-beam effect must be taken into account in evaluation of physical apertures.
 - Horizontal beam parameters change significantly with $\xi_{x0} = 0.276$ and $v_x = .505$,
 - β_x* 20 → 1.9 cm





Physical Aperture

- Requirement : 5 σ_x with beam-beam effect
 - Larger than injection aperture.
 - σ_x must be decreased at QC2LE (HER) and QC2RE (HER).
 - SR fan from $3\sigma_x$ and $3\sigma_{x'}$ should also be considered.
- Increased $\beta_x \approx 20 \rightarrow 40$ cm
 - Luminosity will decrease by ~20 %.



Injection Acceptance

- Injection acceptance is evaluated:
 - HER/LER 4.5E-6/7.5E-6 m w/o Damping Ring
 - HER/LER $1.9E-6/2.6E-6 \rightarrow \sim 1.0E-6$ m with Damping Ring



Optics with New Quads

- To reduce $\beta x^* 40 \rightarrow 20$ cm again with new quads.
 - 1.9K superconducting and permanent quads.
 - Additional horizontal focusing quads for HER.
 - At present, only L-side is acceptable from the view point of σ_{x} and SR fan.



Present Layout



LER Optics

- βx^* is still 40 cm, which is limited by R-side.
- Only L-side with a new superconducting quadrupole.
- Field gradient of QCS's is optimized for LER.



HER Optics

- Only L-side with new quadrupoles.
- Additional horizontal focusing quad (permanent) is introduced.



Low Emittance Option

	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	
к (%)	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	5.25x10 ¹⁰	3.89×10 ¹⁰	8.11x10 ¹⁰	5.52x10 ¹⁰	5.99x10 ¹⁰	
np	12.x10 ¹⁰	6.78x10 ¹⁰	1.39x10 ¹¹	5.52x10 ¹⁰	5.99x10 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	
ξγ	0.30/0.51	0.067/0.068	0.139/0.139	0.147/0.150	0.125/0.126	
Lum	5.3x10 ^{35 a)}	5.0x10 ^{35 b)}	10x10 ^{35 b)}	11x10 ^{35 b)}	10x10 ^{35 b)}	

Y. Funakoshi

Italian version of IP

• $BX^*/BY^* = 20 / .200 \text{ mm}$



A. Morita

Italian version of IP

• Dynamic aperture



A. Morita

Summary

- For high current option, we have not yet found a realistic solution of $\beta_x^* = 20$ cm. At present, β_x^* remains 40 cm.
- Design of low emittance option has just started.
 - Geometry of IR beam lines
 - New layout with 60 mrad crossing angle

Beam size @ IR Q-magnets

 $v_x = .505$ (): 5 σ_x

		QC2LE	QC1RE	QC2RE	QC2LP	QC2RP
b _x *=20cm	8.2	26.9	11.6	28.8	14.7	18.6
QC2RE:元	(41)	(134.5)	(58)	(144)	(73.5)	(93)
b _x *=20cm QC2RE->IP	8.4 (42)	19.0 (95)	12.0 (60)	20.7 (103.5)		
b _x *=40cm	5.9	13.4	8.5	14.6	9.8	12.3
QC2RE->IP	(29.5)	(67)	(42.5)	(73)	(49)	(61.5)

			QC1LE	QC2LE	QC1RE	QC2RE	QC2LP	QC2RP
	Field gradient	T/m	15.5	3.4	12.0	8.8	6.7	3.4
	Pole length	m	0.64	2.0	0.75	0.8	0.6	1.0
k	bore radius	mm	25	50	48	90	80	40
	Current	AT	3920	3400	11050	28400	17100	1980
	coil turns	/pole	3	8	3	16	15	3
(Current density of							
1	Septum conductor	A/mm^2	30	10	70	24	31	15
F	ield in the area for	-						
cou	ter-circulating beam	Gauss	$0\sim$ - 0.65	$0\sim$ - 0.4	$0 \sim -1.1$	$0\sim$ - 0.35	$0\sim$ - 0.85	$0\sim$ - 0.35

Table 3.3: Parameters of special quadrupole magnets

