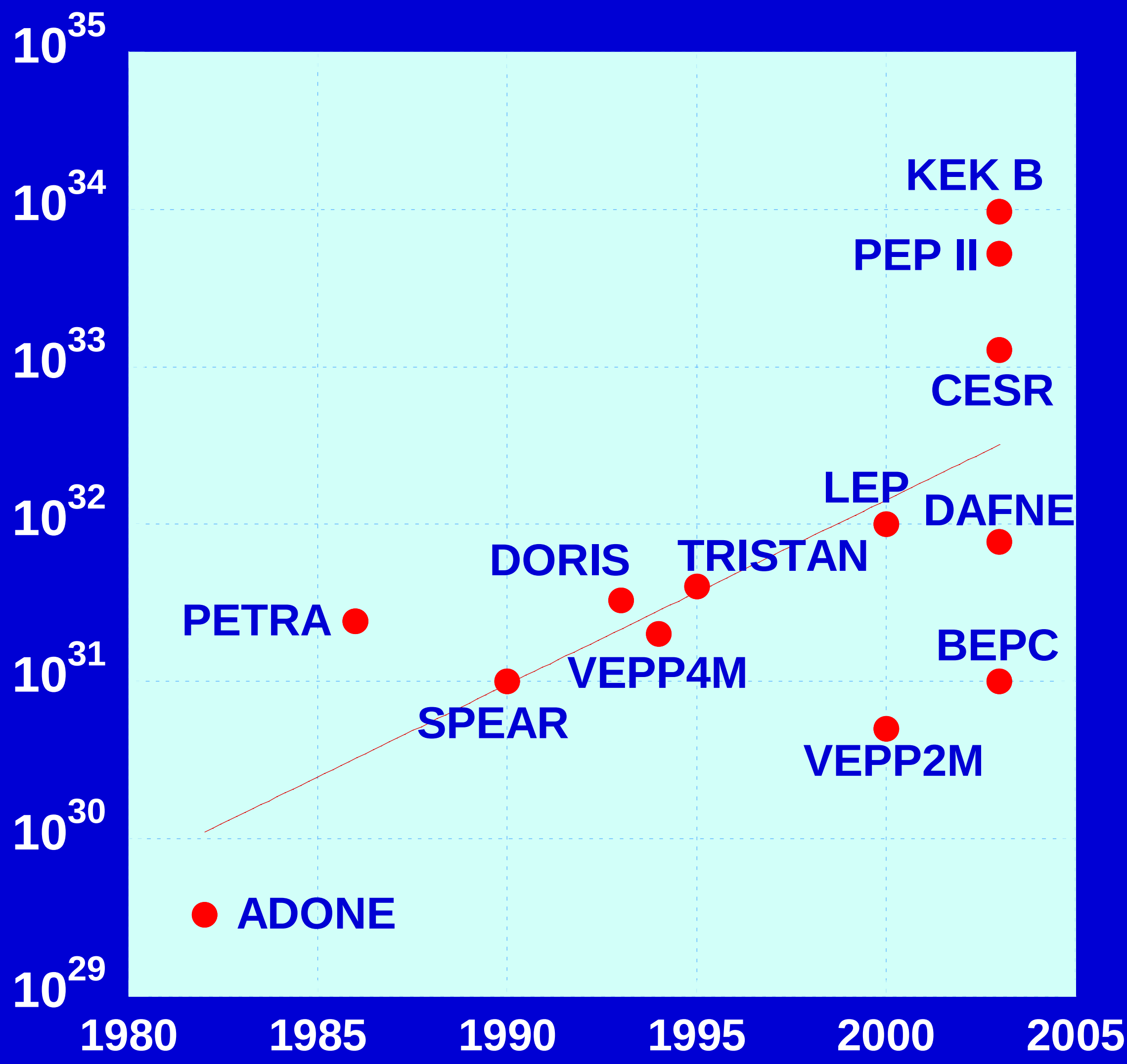
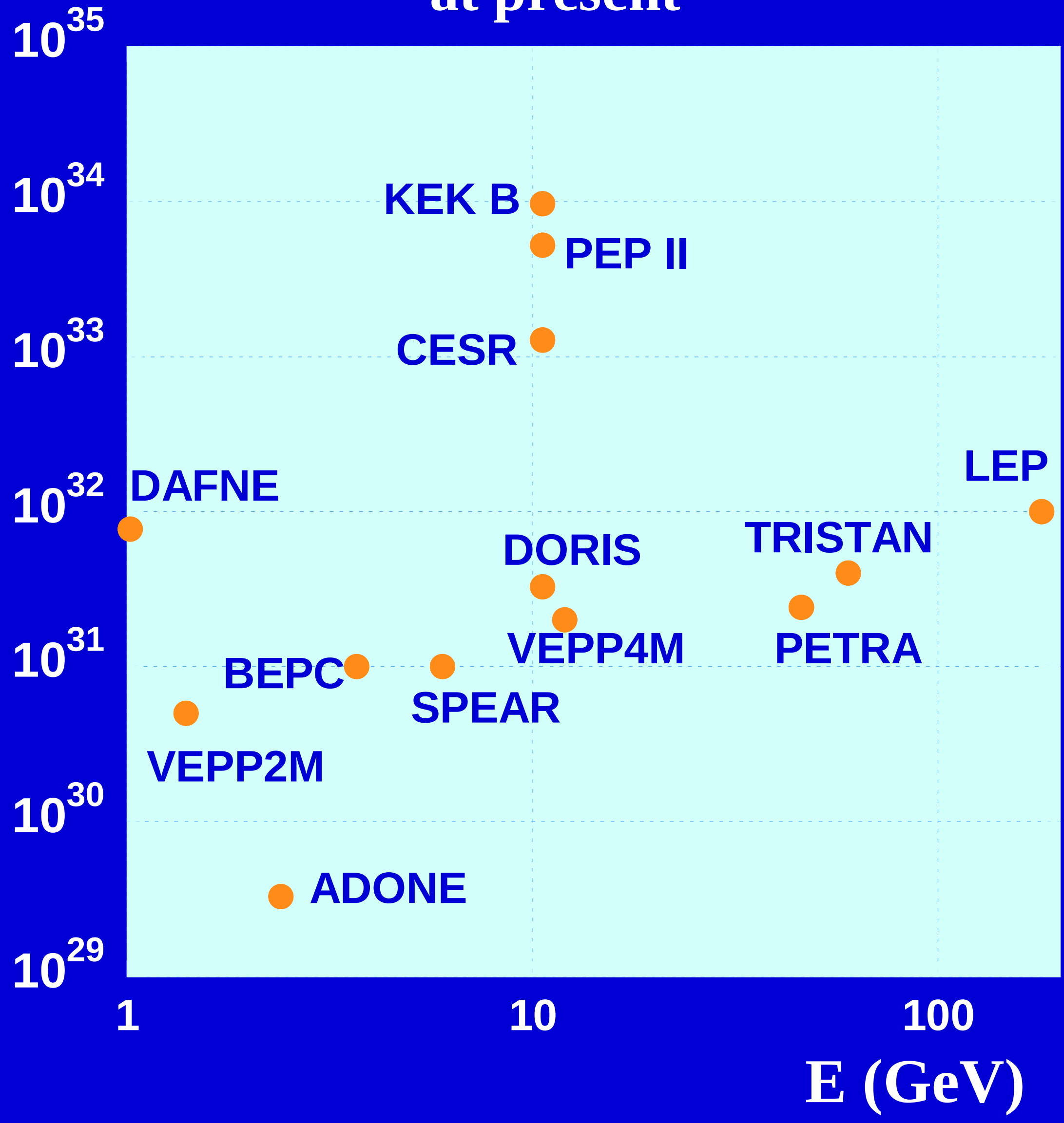
Upgrades of Particle Factories

C. Biscari
LNF - INFN

LUMINOSITY / TIME until 2003
e+ e- circular colliders



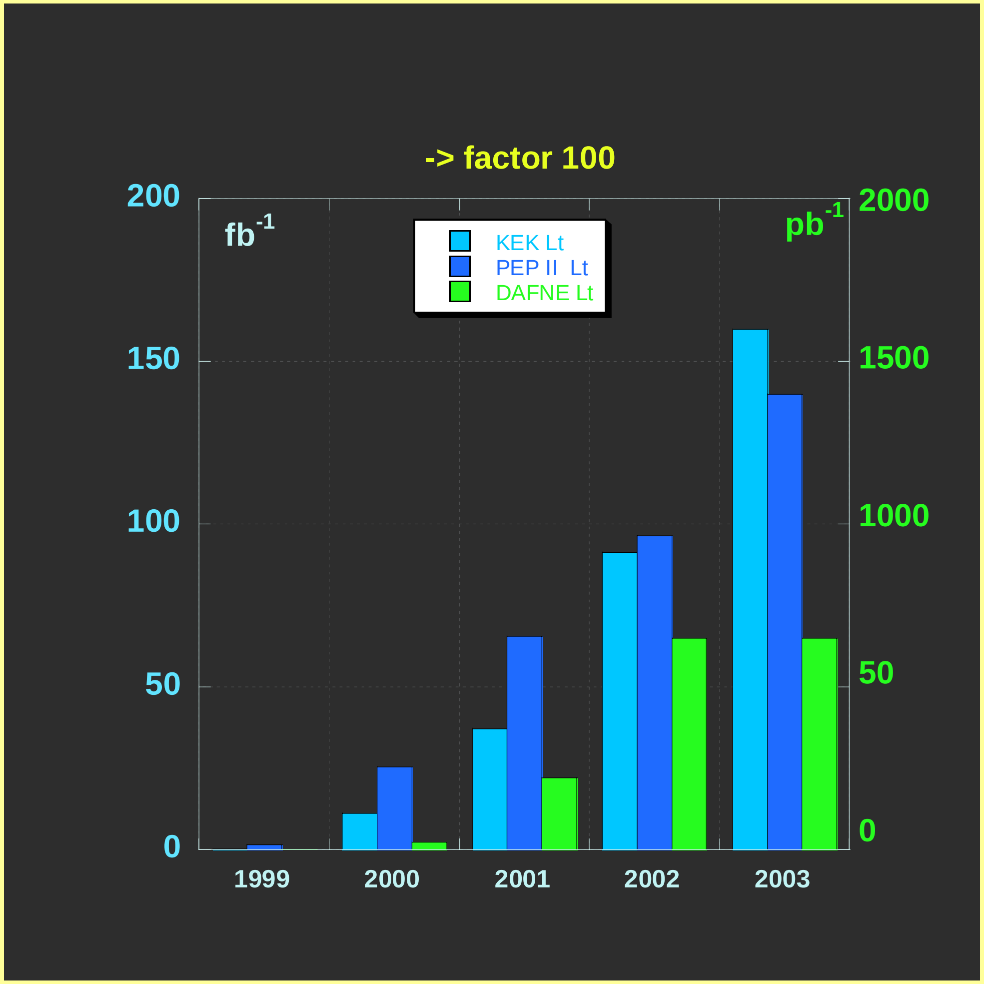
LUMINOSITY / ENERGY CM (GeV) at present



The annihilation production cross section in e^+e^- collisions and the necessary integrated luminosity scale with Energy:

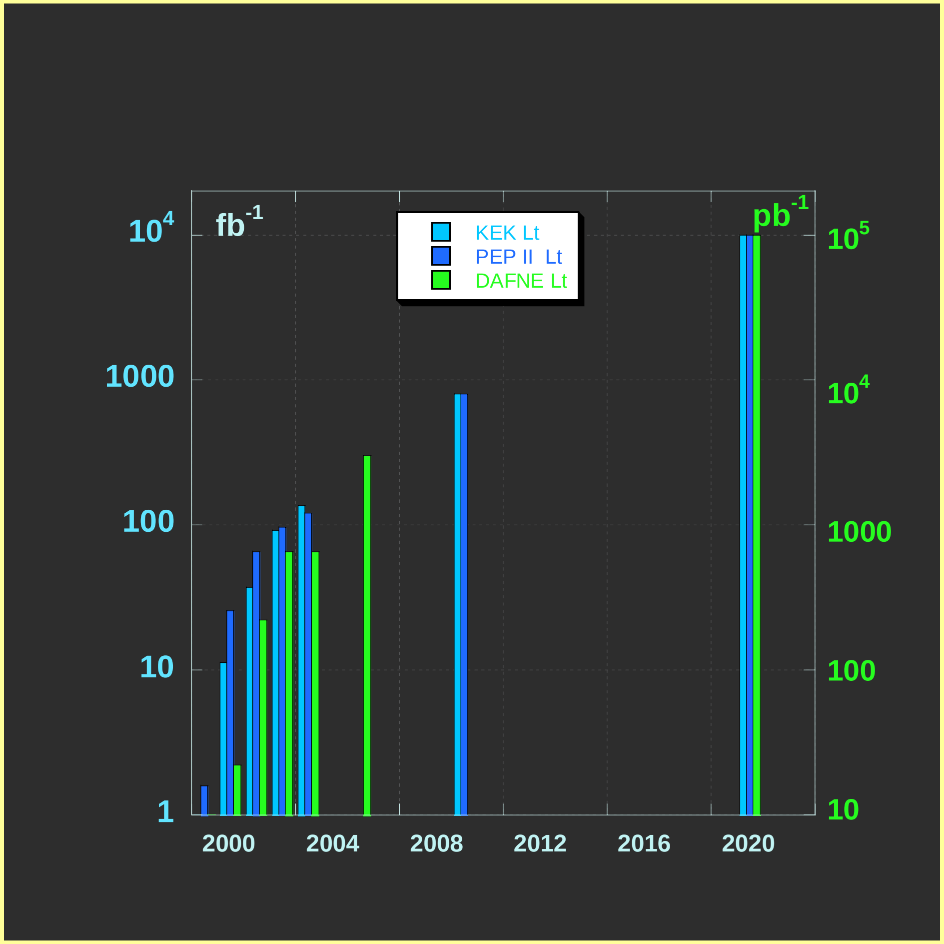
$$L \propto \frac{1}{\sigma} \propto E^2$$

Integrated luminosity by KEKB, PEPII and DAΦNE

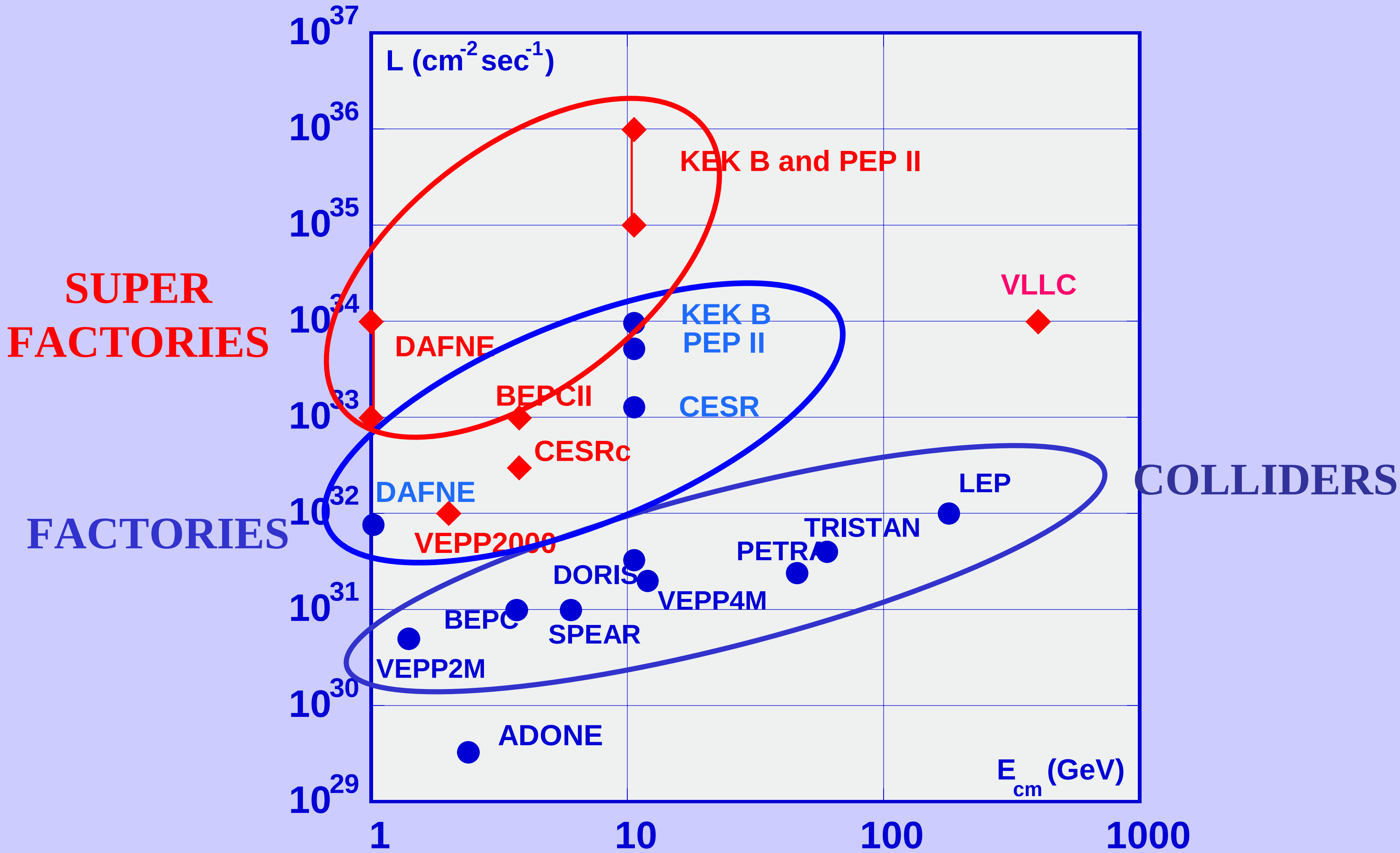


	E_{cm} GeV	logged $\int L$	requested $\int L$
B	10.6	~ 300 fb^{-1}	10ab^{-1}
τ	3.9	< 1 fb^{-1}	>100fb^{-1}
light quarks	2	< 10pb^{-1}	500pb^{-1}
Φ	1	< 1 fb^{-1}	> 100fb^{-1}

requested $\int L$ for next collider generations



PAST, PRESENT AND FUTURE

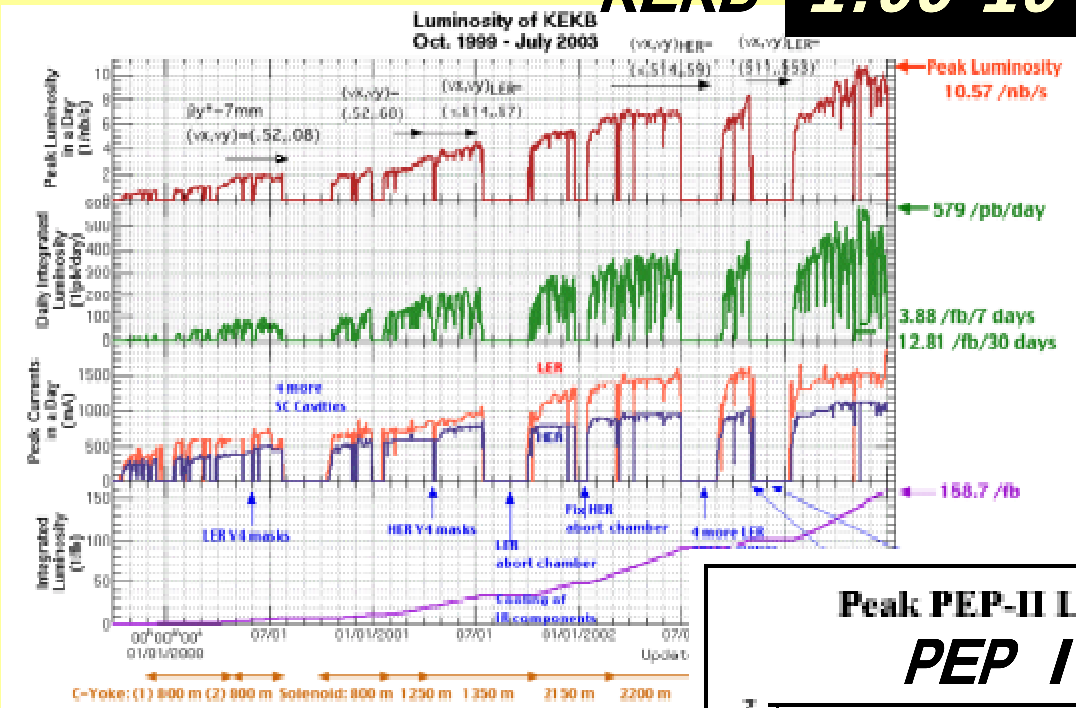


e+e- in the 1-2 GeV range: -
September 2003

B-Factories

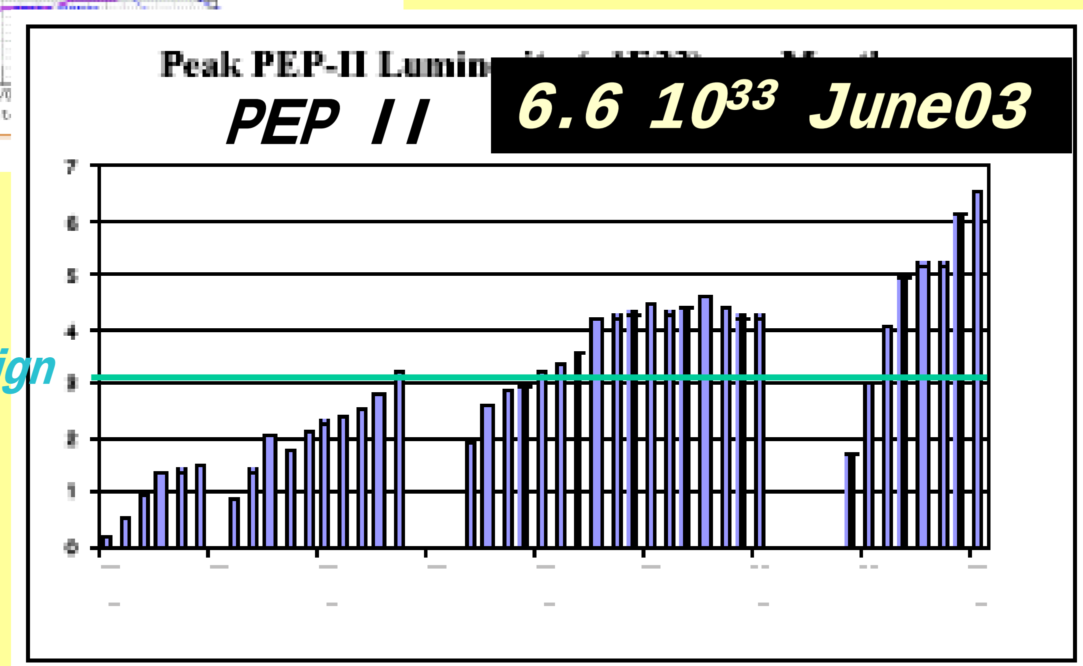
	E_{cm} (GeV)	L_{now}	L_{future}
KEK-B	10.6	$1.06\ 10^{34}$	*10^{36}*
PEP-II	10.6	$6.6\ 10^{33}$	*10^{36}*
CESR	3-10.6	$1.3\ 10^{33}$	*$0.15\text{-}1.3\ 10^{33}$*
BEPC	2 – 5.6	10^{31}	*10^{33}*
VEPP2000	1 - 2	_	*10^{32}*
DAFNE2	*2*	_	*10^{32}*
DAΦNE	1	$7.8\ 10^{31}$	*$>10^{33}$*

KEKB **1.06 10^{34} May03**



present status

PEP II **6.6 10^{33} June03**

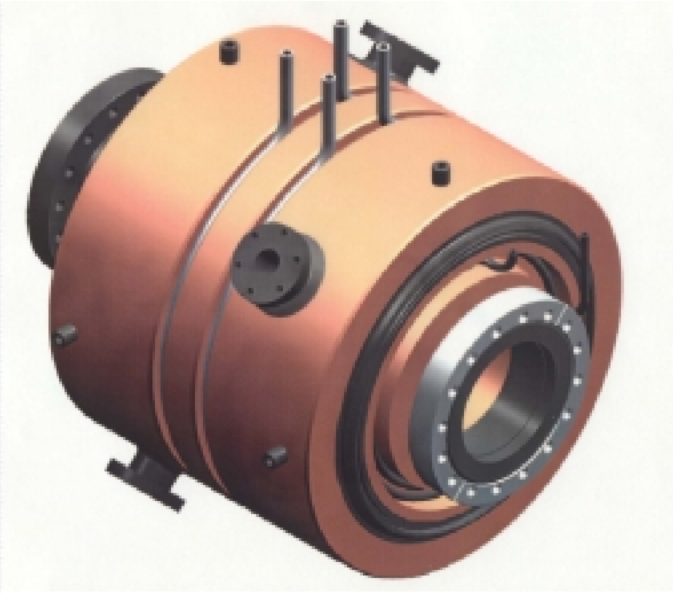


e+e- in the 1-2 GeV range: -
September 2003

super B factories

	KEK-B		PEP II		
	Super	Hyper	next	Super	Hyper
E + (GeV)	3.5	3.5	3.1	3.5	3.5
E - (GeV)	8.0	8.0	9.0	8.0	8.0
C (m)	3016	3016	2199	2199	2199
L (10^{34} $cm^{-2}s^{-1}$)	10	40-100	2.5 - 4	20	100
β* (m) (h)	30	15	0.5	0.3	0.15
β* (m) (v)	0.003	0.003	0.0065	0.0037	0.0015
ε (n rad) (h)	33	33	44	44	44
ε (n rad) (v)	2	0.33	0.44	0.44	0.44
θ (mrad)	15	0	0 - 4	10	15
ξ (h)	0.068	0.1	0.08	0.10	0.10
ξ (v)	0.05	0.2	0.08	0.10	0.10
N bunches	5018	5018	1700	3400	7000
I+ (A)	9.4	17.2	4.5	11.0	10.3
I - (A)	4.1	7.8	2.0	4.8	2.35
f_{RF} (MHz)	509	509	476	476	952

10^{34} PEP II



increase n. of bunches
increase currents
feedback – substitute longitudinal kicker
add solenoids - ECI
MIA (correction algorithm)

2-4 10^{34} PEP II

lowering β_y
increase rf power
shortening bunch length
increase nb (4 nsec spacing) ->1700 (x2)
small $\theta \sim 4$ mrad

10^{35} PEP II

Increase n of bunches x 2
feedback upgrade (2 nsec)
diminish beam asymmetry

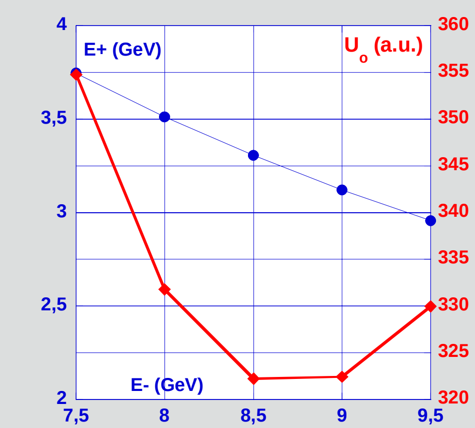
lowering β_y : nearer quads IP
increase N+ N-
increase ε_x
increase $\theta \sim 10\,mrad$

$$E_{cm} = \sqrt{4E^+E^-}$$

$$\frac{N^+}{E^-} = \frac{N^-}{E^+}$$

$$\rho^- \approx 10\rho^+$$

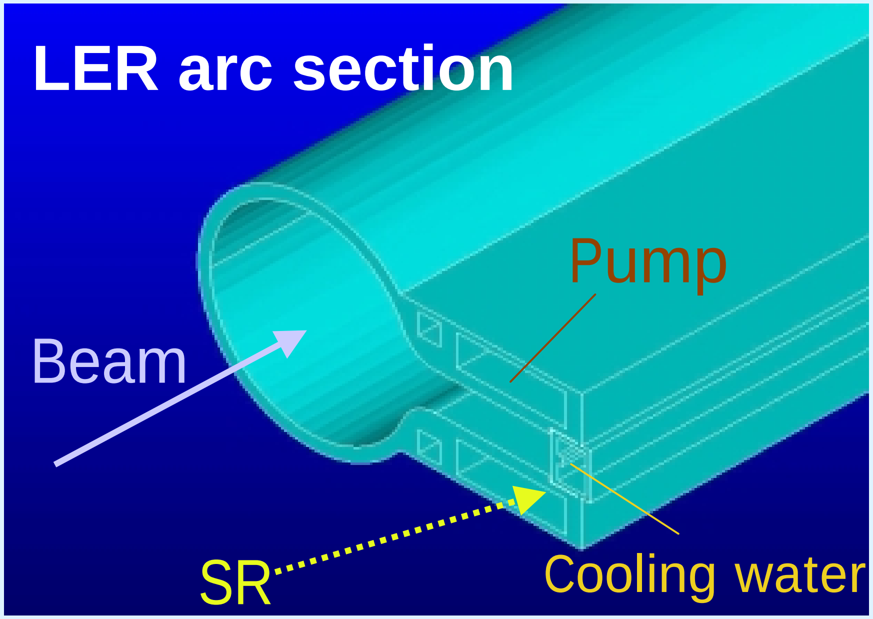
$$U_o \propto \frac{I^+E^{+4}}{1} + \frac{I^-E^{-4}}{10}$$



10^{35} *KEK-B*

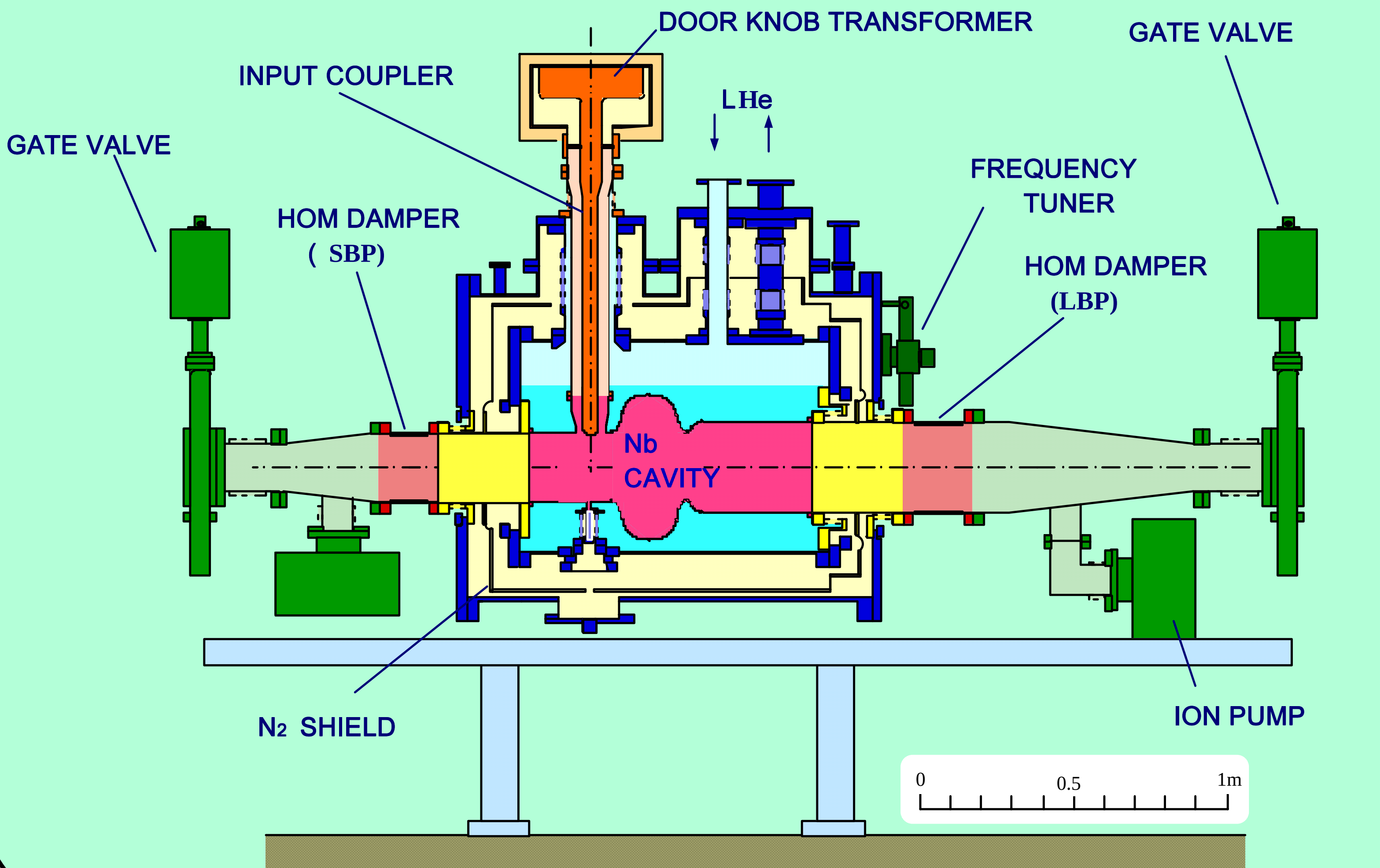
Increase n of bunches x4
lowering β_y
increase N+ N-
increase ε_x
increase rf power

vacuum chamber design
rfshields
beam energy switch for ECI

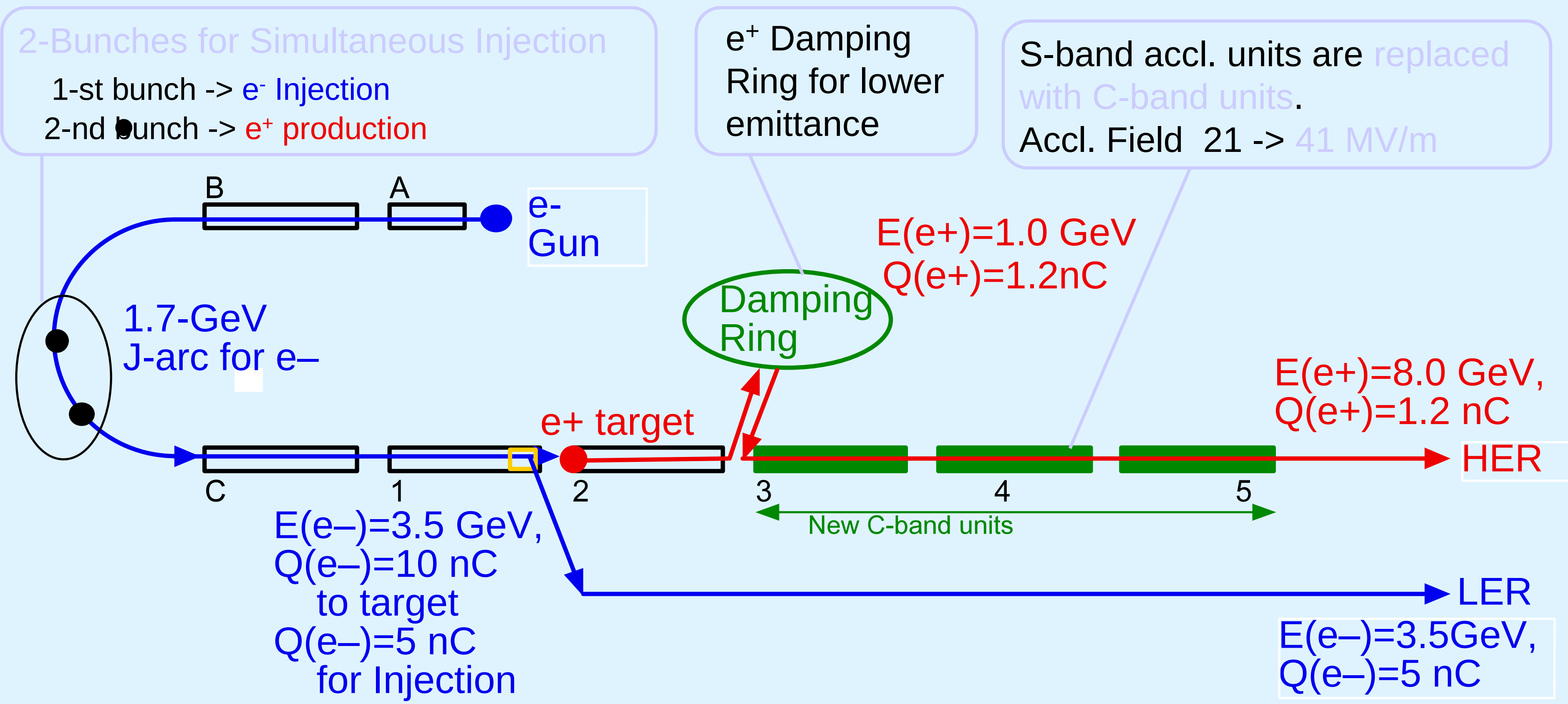


Superconducting Damped Cavity for KEKB

T. Furuya

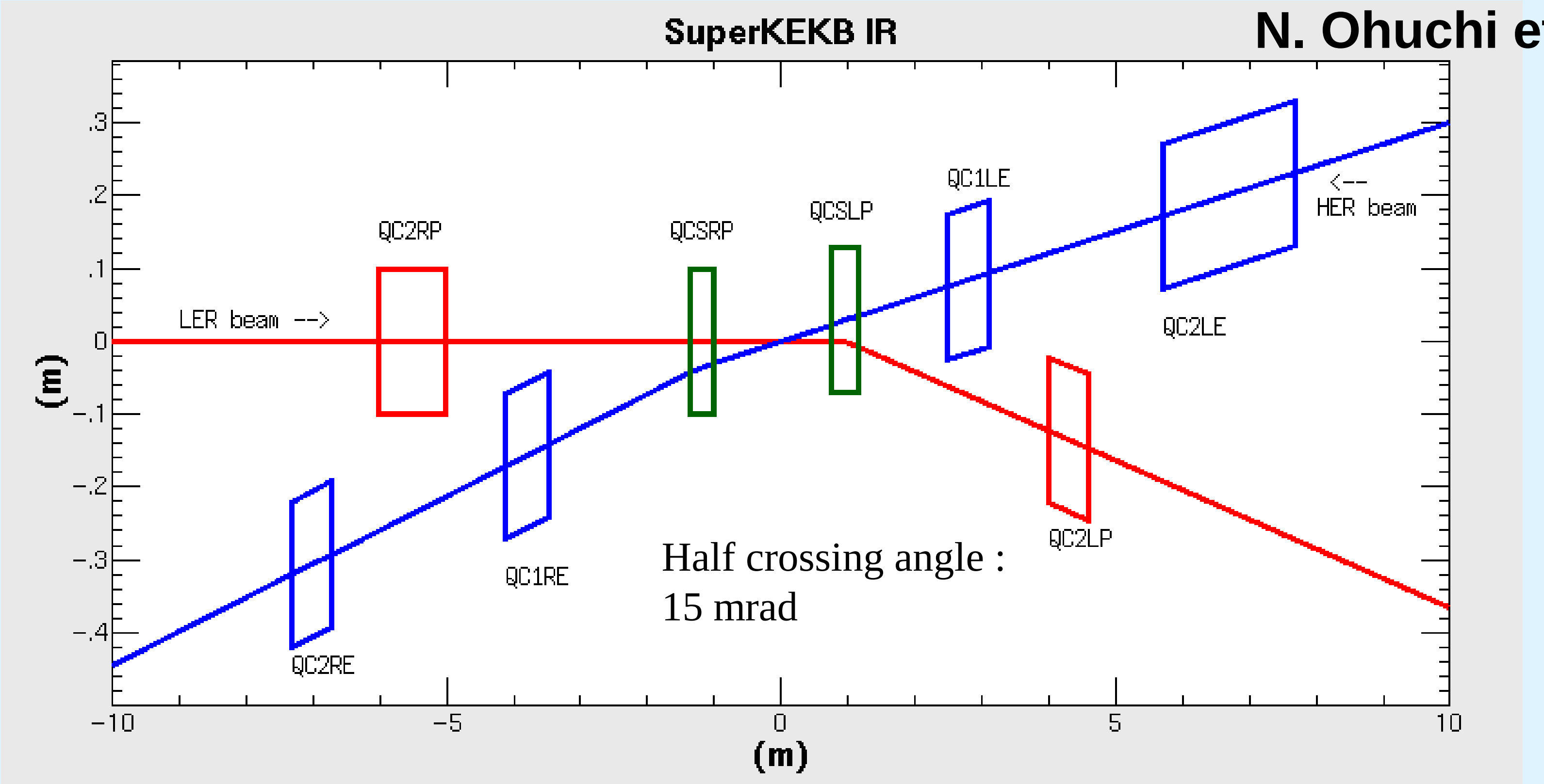


Higher acceleration field scheme for 8 GeV e+



Layout of beam lines at IR

N. Ohuchi et al.



Final focusing quadrupoles (QCS) locate at the position as close to the IP as possible.

Pos. from the IP	Super-KEKB	KEKB
QCS-R	1163.3 mm	1920 mm
QCS-L	969.4 mm	1600 mm

The QCS magnets are overlaid with the compensation solenoids (ES).

→ compact & short in z

10^{36} PEP II

Increase n of bunches x 2 :
7000

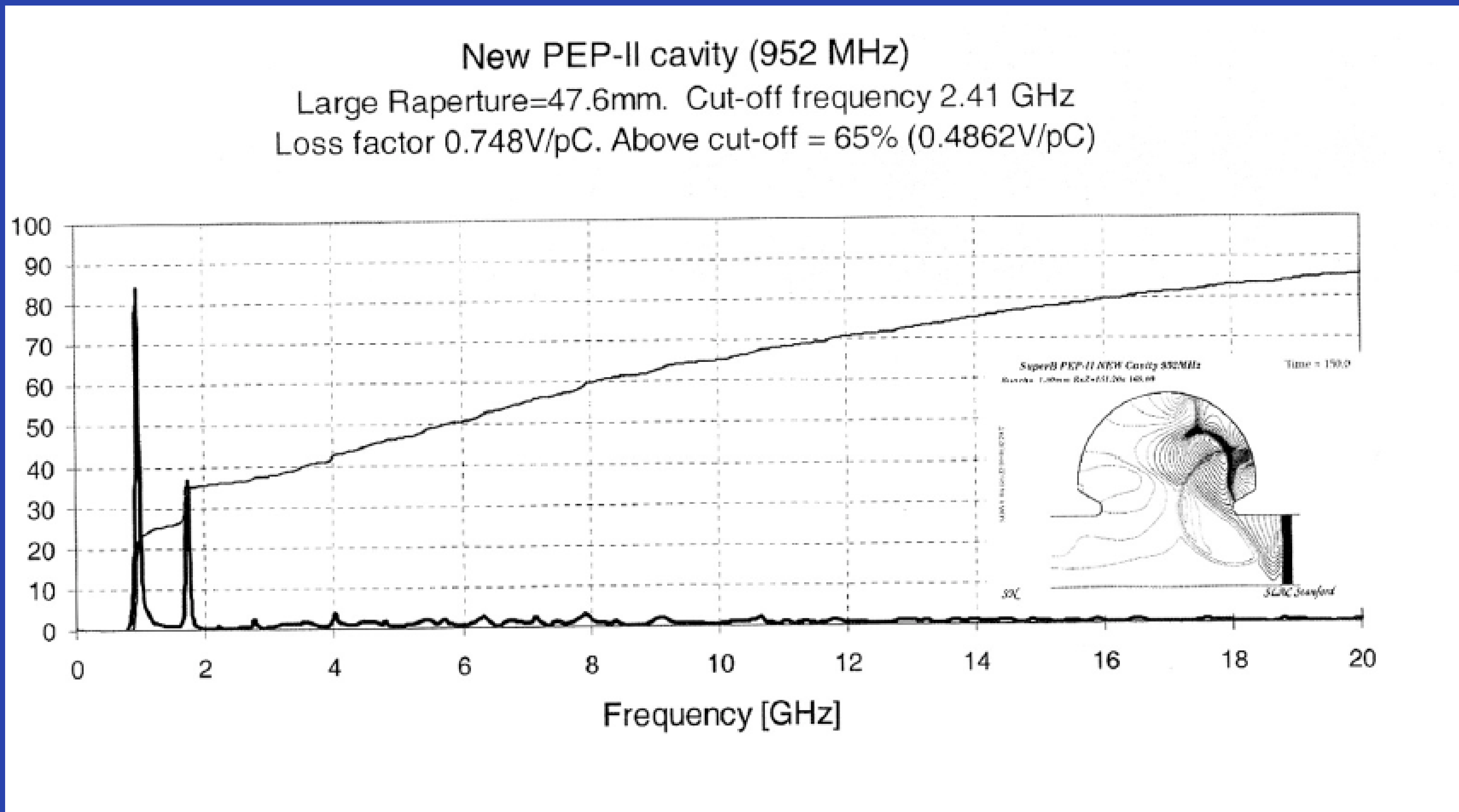
f_{rf} x2 : 950 MHZ

feedback upgrade (<1 nsec)

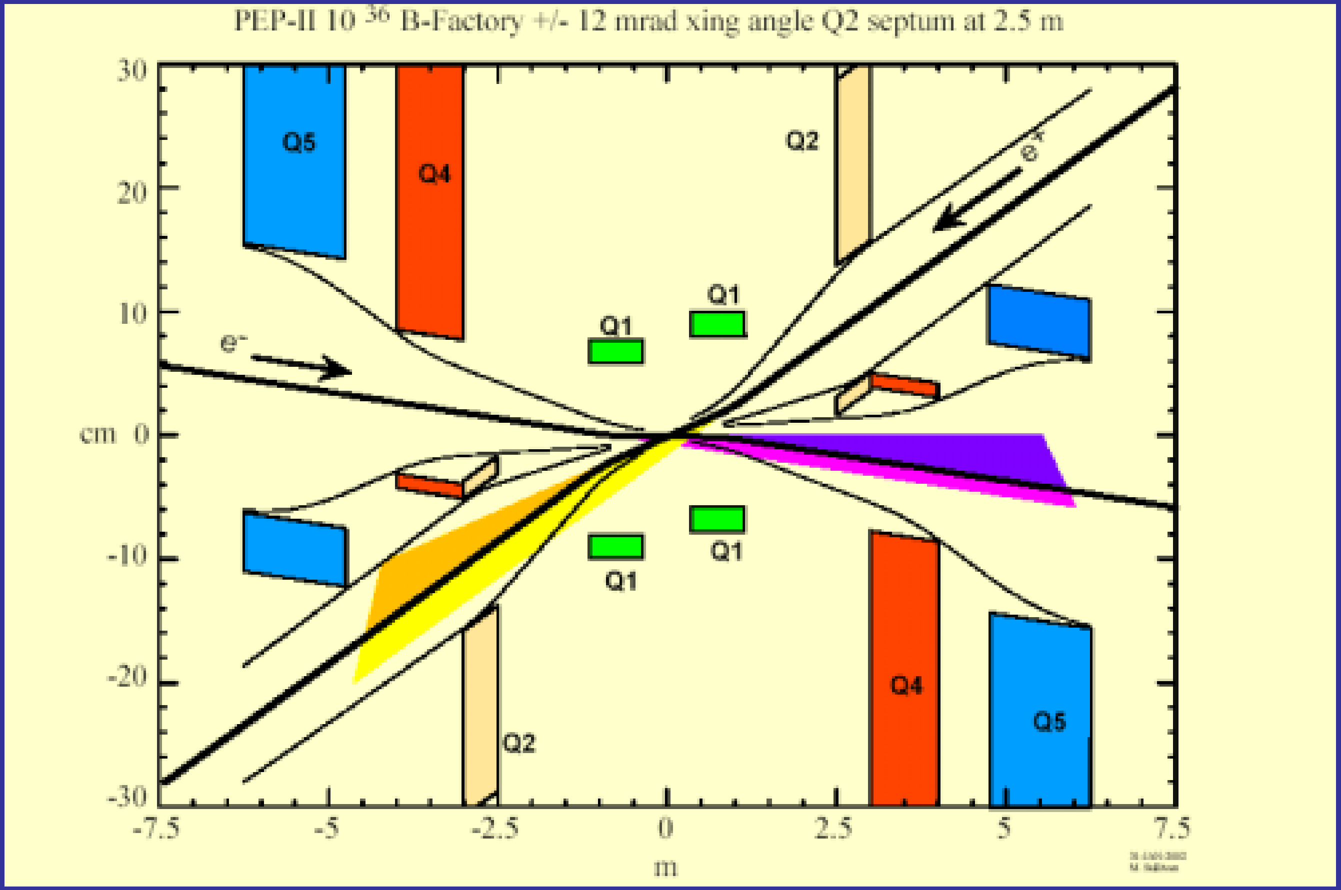
lowering β_y nearer quads iP

decrease N+ N-

increase $\theta \sim 15$ mrad


New PEP-II cavity (952 MHz)
Large Raperture=47.6mm. Cut-off frequency 2.41 GHz
Loss factor 0.748V/pC. Above cut-off = 65% (0.4862V/pC)
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
Frequency [GHz]

PEP-II IR for L = 10^{36}



10^{36} *KEK-B*

Increase bunch current x 2

(I^+ 17A, I^- 8A)

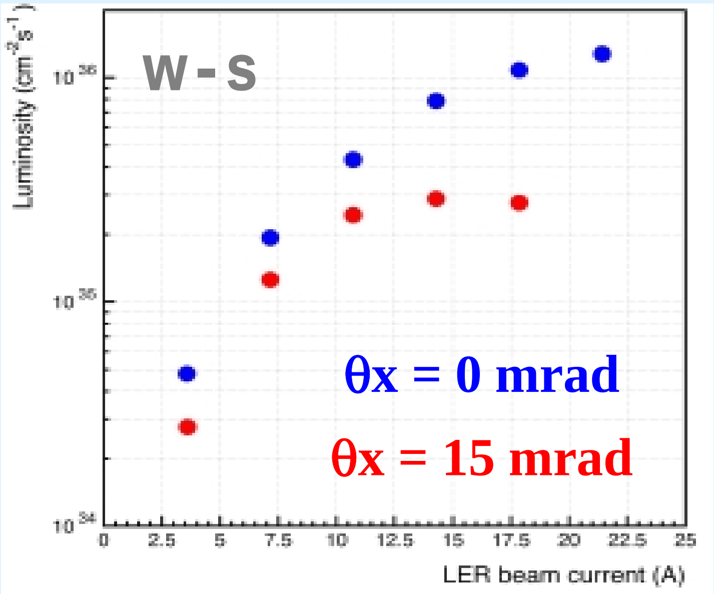
same n_b

b-b with crab crossing

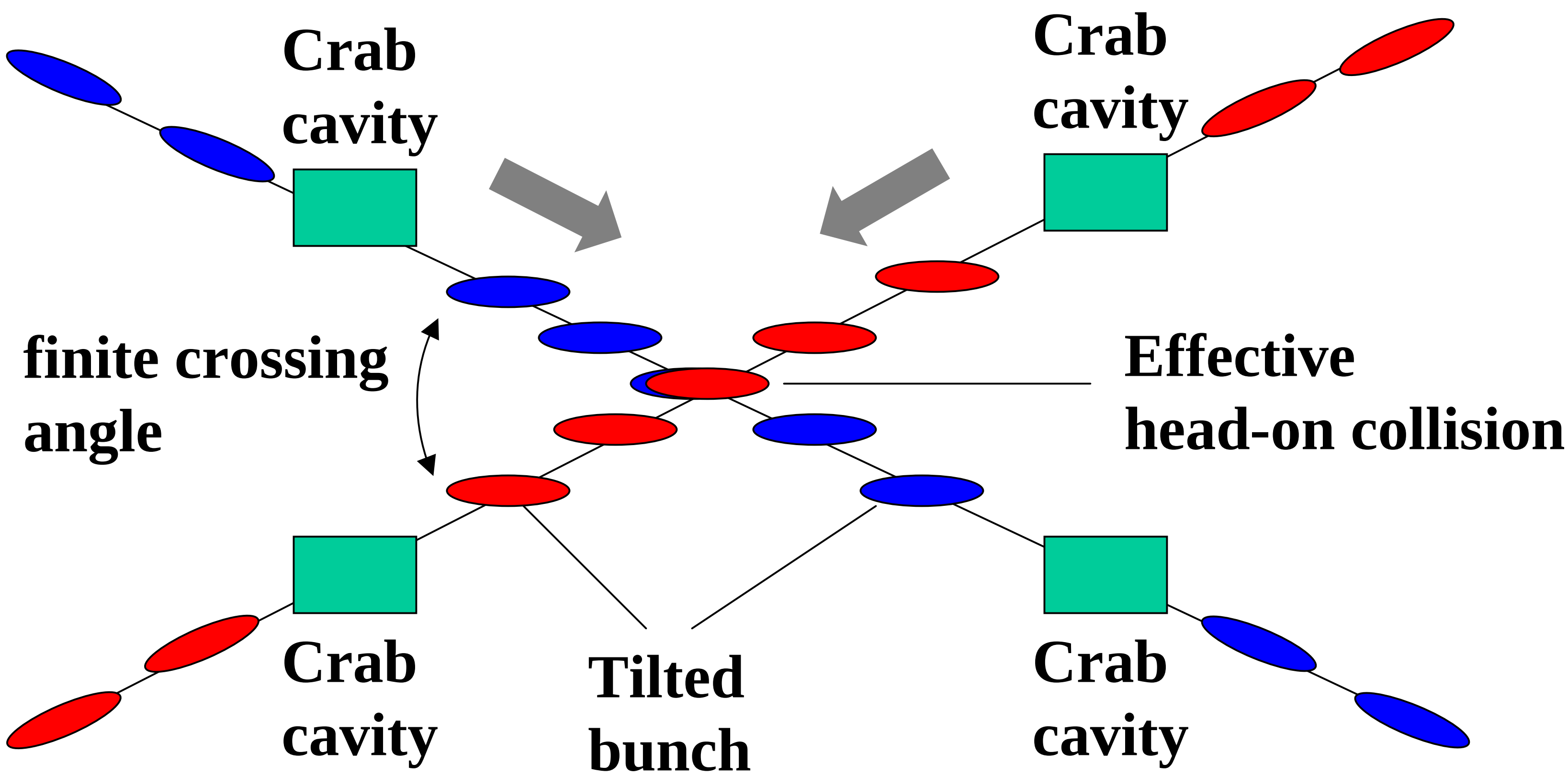
0 crossing angle

lower coupling

high b-b tune shift



Crab crossing



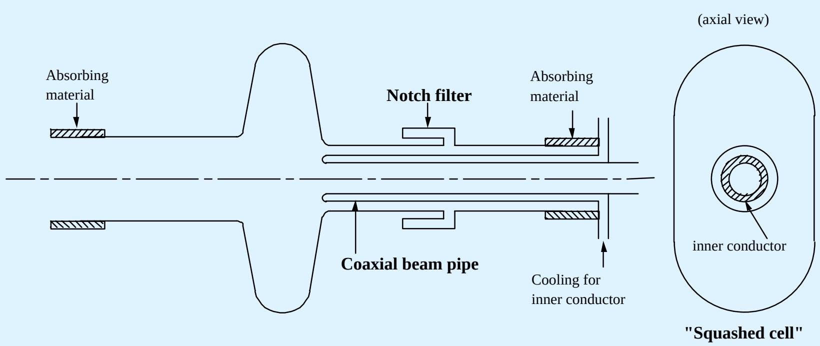
- Bunches are tilted by crab cavities.

Present design for KEKB test before 2005

K. Hosoyama and K. Akai et al.

Crab cavity

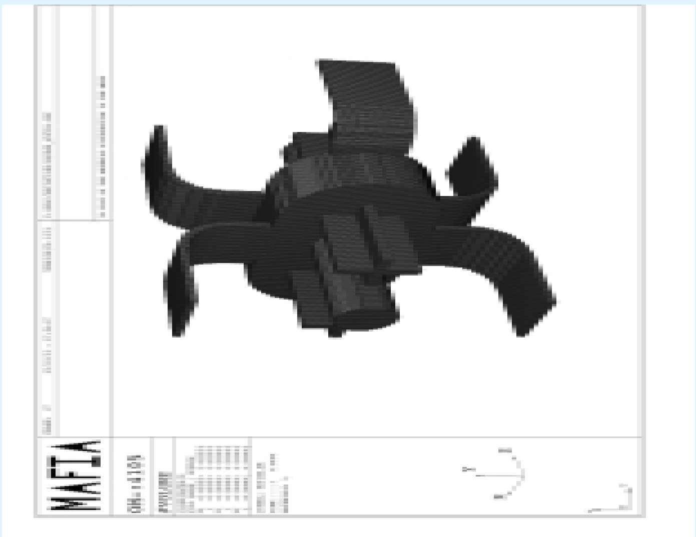
- Squashed cell operating in TM2-1-0 (x-y-z)
- Coaxial beam pipe + HOM dampers
- Designed for 1– 2A beam



Squashed Crab cavity for B-factories

(K. Akai et al., Proc. B-factories, SLAC-400 p.181 (1992).)

- Squashed cell operating in TM2-1-0
- HOM damping using wave guides without coaxial beam pipe damper



New design for SuperKEKB, 10A beam

super B factories

	KEK-B		PEP II		
	Super	Hyper	next	Super	Hyper
E + (GeV)	3.5	3.5	3.1	3.5	3.5
E - (GeV)	8.0	8.0	9.0	8.0	8.0
C (m)	3016	3016	2199	2199	2199
L (10^{34} $cm^{-2}s^{-1}$)	10	40-100	2.5 - 4	20	100
β* (m) (h)	30	15	0.5	0.3	0.15
β* (m) (v)	0.003	0.003	0.0065	0.0037	0.0015
ε (n rad) (h)	33	33	44	44	44
ε (n rad) (v)	2	0.33	0.44	0.44	0.44
θ (mrad)	15	0	0 - 4	10	15
ξ (h)	0.068	0.1	0.08	0.10	0.10
ξ (v)	0.05	0.2	0.08	0.10	0.10
N bunches	5018	5018	1700	3400	7000
I+ (A)	9.4	17.2	4.5	11.0	10.3
I - (A)	4.1	7.8	2.0	4.8	2.35
f_{RF} (MHz)	509	509	476	476	952

τ-charm factories

	E_{cm} (GeV)	L_{now}	L_{future}
KEK-B	**10.6**	**9.7 10^{33}**	***10^{36}***
PEP-II	**10.6**	**5.2 10^{33}**	***10^{36}***
CESR	**3-10.6**	**1.3 10^{33}**	**0.15-1.3 10^{33}**
BEPC II	**2 – 5.6**	**10^{31}**	**10^{33}**
VEPP2000	**1 - 2**	**_**	**10^{32}**
DAFNE2	***2***	**_**	***10^{32}***
DAΦNE	**1**	**7.8 10^{31}**	***>10^{33}***

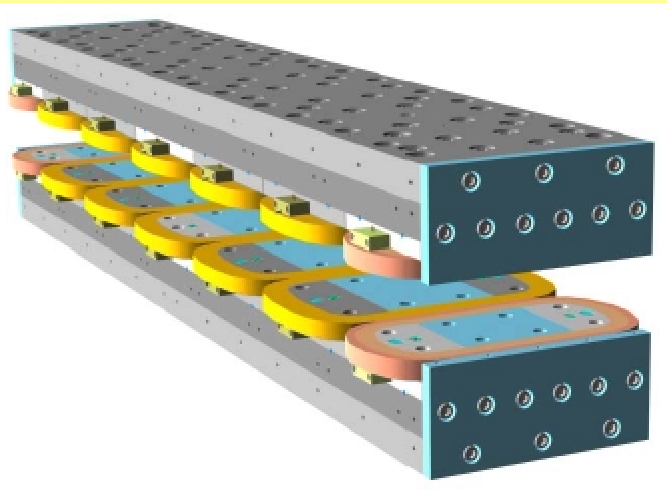
τ-charm factories

Collider	CESRc[2]	BEPC II [3]
status	operating	in construction
E (GeV)	1.88	1.89
C (m)	768	237.5
L (10^{32} $cm^{-2}s^{-1}$)	3	10
rings	1	2
IPs	1	1
β^* (m) (h / v)	0.7/ 0.011	1 / .015
ε (μ rad) (h / v)	0.22	0.17 / 0.002
θ (mrad)	±2.8	± 11
ϕ (rad)	0.07	0.4
σ_z (cm)	1.0	1.5
N_b (10^{10})	6.4	4.8
ξ (h / v)	0.03 / 0.03	0.04 / 0.04
N bunches	45	93
I (A)	.18	0.91
f_{RF} (MHz)	500.0	499.8
V (MV)	10	1.5

CESRc

6 wigglers installed and in commissioning
Run @ 3 GeV since April '03

Other 6 wigglers will be installed in one year and CESR will run until 2008 at three energies between 3.1 and 4.1 GeV

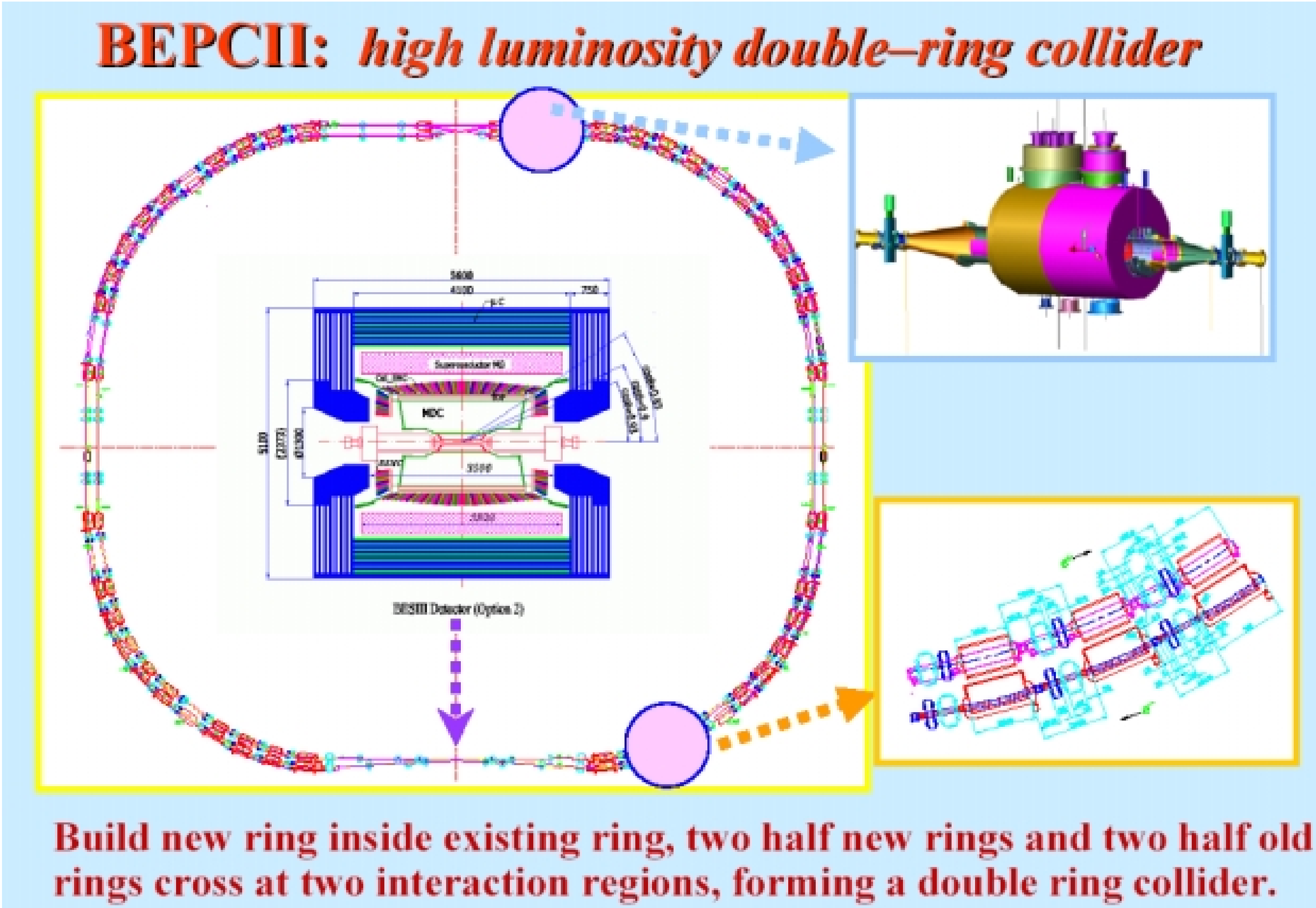


. Table 1: Parameters with and without wigglers (1.9 GeV)

Parameter	No Wigglers	18m 2.1T wigglers
ε_X	30	220 nm-rad
Damping time	570	55 ms
σ_E/E_0	2×10^{-4}	8×10^{-4}

Table 2: CESR-c Parameters

E_0 [GeV]	1.55	1.88	2.5	5.3
Luminosity [$\div 10^{30}$ cm^{-2}-sec^{-1}]	150	300	500	1250
i_b [mA/bunch]	2.8	4.0	5.1	8.2
I_{beam} [mA/beam]	130	180	230	360
ξ_y	0.035	0.04	0.04	.06
ξ_x	0.028	0.036	0.034	.028
σ_E/E_0 [x10^3]	0.75	0.81	0.79	0.67
$\tau_{x,y}$ [ms]	69	55	52	22
B_W [Tesla]	2.1	2.1	1.75	0
β_y^* [cm]	1.0	1.0	1.0	1.8
ε_x [nm-rad]	230	220	215	205



Commissioning by 2006

e+e- in the 1-2 GeV range: -

September 2003

Light Quark Factories

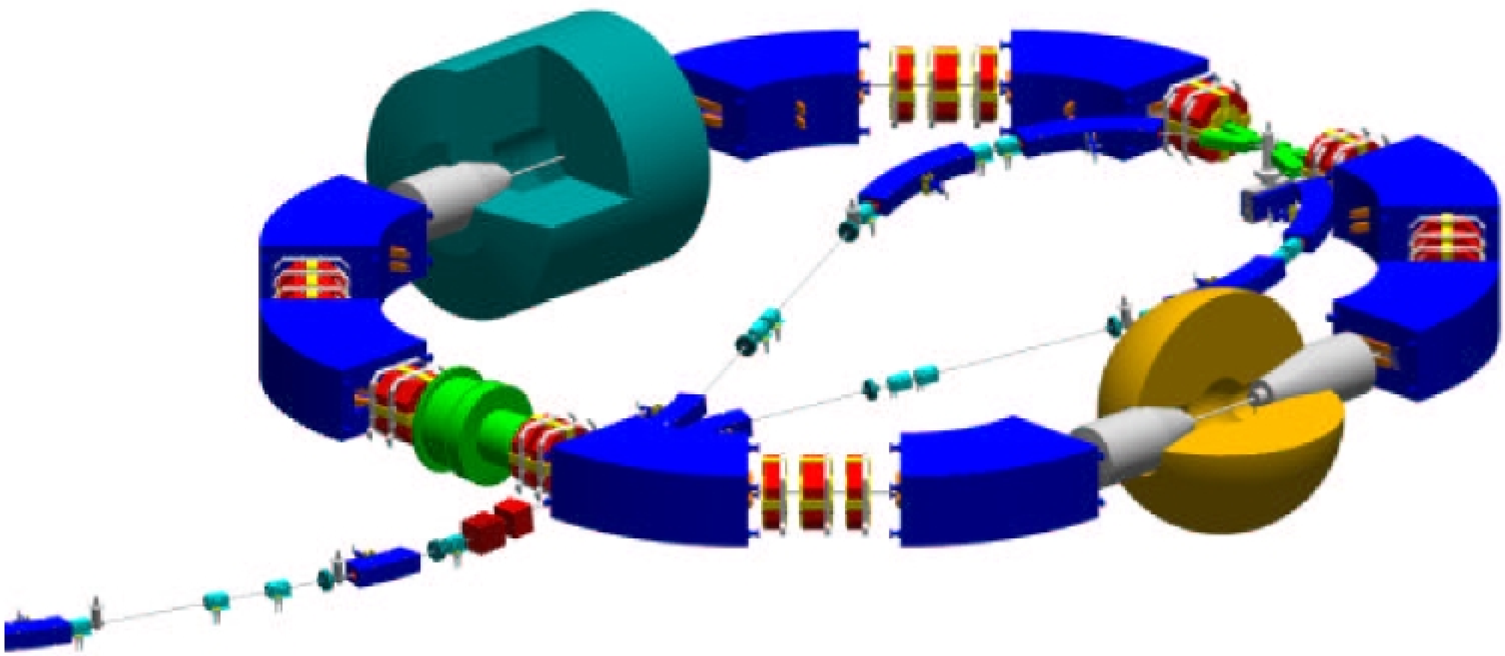
	E_{cm} (GeV)	L_{now}	L_{future}
KEK-B	**10.6**	**9.7 10^{33}**	***10^{36}***
PEP-II	**10.6**	**5.2 10^{33}**	***10^{36}***
CESR	**3-10.6**	**1.3 10^{33}**	**0.15-1.3 10^{33}**
BEPC	**2 – 5.6**	**10^{31}**	**10^{33}**
VEPP2000	**1 - 2**	**_**	**10^{32}**
DAFNE2	***2***	**_**	***10^{32}***
DAΦNE	**1**	**7.8 10^{31}**	***$>10^{33}$***

Light Quark Factories

Collider	VEPP2000	DAFNE 2
status	in construction	design study
E (GeV)	1.	1.
C (m)	24	97
L (10^{32} $cm^{-2}s^{-1}$)	1	1
IPs	2	1
β^* (m) (h / v)	0.1 / 0.1	1.5 / 0.025
ε (μ rad) (h / v)	0.136 / 0.136	0.5 / 0.0025
θ (mrad)	0	± 15
ϕ (rad)	0	0.26
σ_z (cm)	3	1.1
N_b (10^{10})	10	3
ξ (h / v)	0.1 / 0.1	0.014 / 0.024
N bunches	1	30
I (A)	0.20	0.45
f_{RF} (MHz)	172	368.3
V (MV)	0.12	0.25

View of the VEPP-2000 collider

Experimental testing of RCB should verify predictions on extremely high attainable space charge parameters for the round beams.



DAFNE2 (2 GeV, Frascati)

Feasibility study

"Easier" luminosity than at Φ

Naturally increase radiation damping and lifetime

b-b tune shifts / 2

shorter bunch length (I_{thrs} *10) -> lower β_y

roughly same L with I/2 and N_b = 3/5

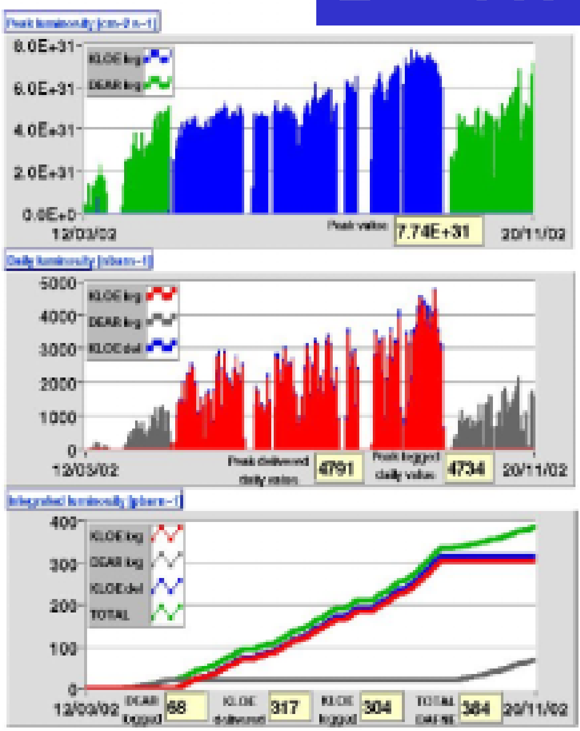
hardware: dipoles, splitters, 20% of quads, IR

Φ-Factories

	E_{cm} (GeV)	L_{now}	L_{future}
KEK-B	10.6	$9.7\ 10^{33}$	*10^{36}*
PEP-II	10.6	$5.2\ 10^{33}$	*10^{36}*
CESR	3-10.6	$1.3\ 10^{33}$	$0.15\text{-}1.3\ 10^{33}$
BEPC	2 – 5.6	10^{31}	10^{33}
VEPP2000	1 - 2	_	10^{32}
DAFNE2	*2*	_	*10^{32}*
DAΦNE	1	$7.8\ 10^{31}$	*$>10^{33}$*

$DA\Phi NE$

$L = 7.7\ 10^{31}$



Restarting now with two solenoidal detectors after a long shutdown

3 fb^{-1} by end 2005

Φ - factories

Collider	DAΦNE
status	until 2005
E (GeV)	.51
C (m)	97
L (10^{32} $cm^{-2}s^{-1}$)	> 1
IPs	1
β* (m) (h / v)	1 / 0.025
ε (μ rad) (h / v)	0.6 / 0.006
θ (mrad)	± 16
ϕ (rad)	0.39
σ_z (cm)	2
N_b (10^{10})	3.6
ξ (h / v)	0.027 / 0.043
N bunches	100
I (A)	1.8
f_{RF} (MHz)	368.3
V (MV)	0.2

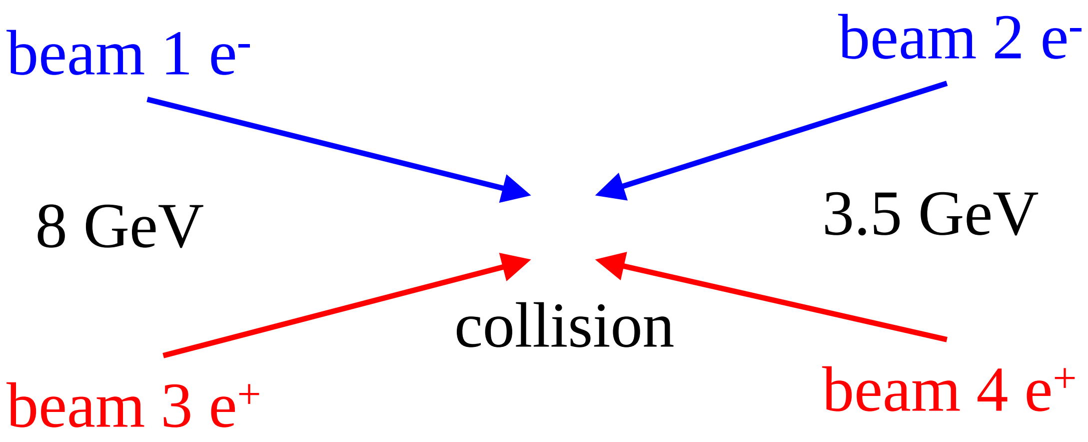
Super Φ factory

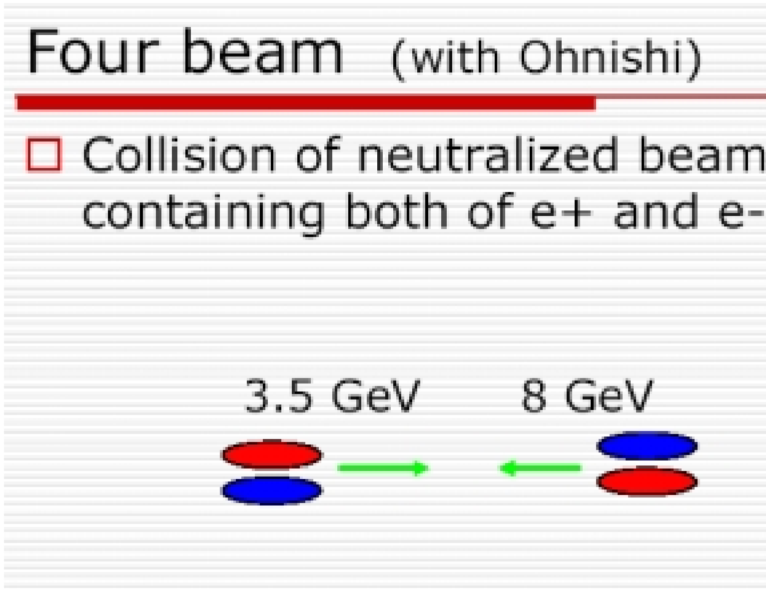
10^{33} attainable stressing present design
10^{34} needs new ideas

‘non conventional’ L

Four beams

- Why four beams ?
  - Four beams is one method to compensate beam-beam effect to increase luminosity.
  - The colliding bunches have neutral net charges and produce no beam-beam forces.
  - This scheme was studied at DCI (Orsay) in ~1971(?).
    - Beam-beam limit was not significantly different from two beams. (G. Arzelia et al.)





Ohmi-Ohnishi et al
KEKB

- **We observe coherent motion in horizontal and incoherent motion in vertical.**
- **Stable region for tunes is very small.**
- **Vertical incoherent motion seems to be correlated with horizontal coherent dipole motion.**
- **Feedback system may help to damp coherent dipole motions.**
- **Beam-beam compensation is not so good compared with four beams. (Quadrupole and octupole motions near resonance)**

negative momentum compaction

ring against linac

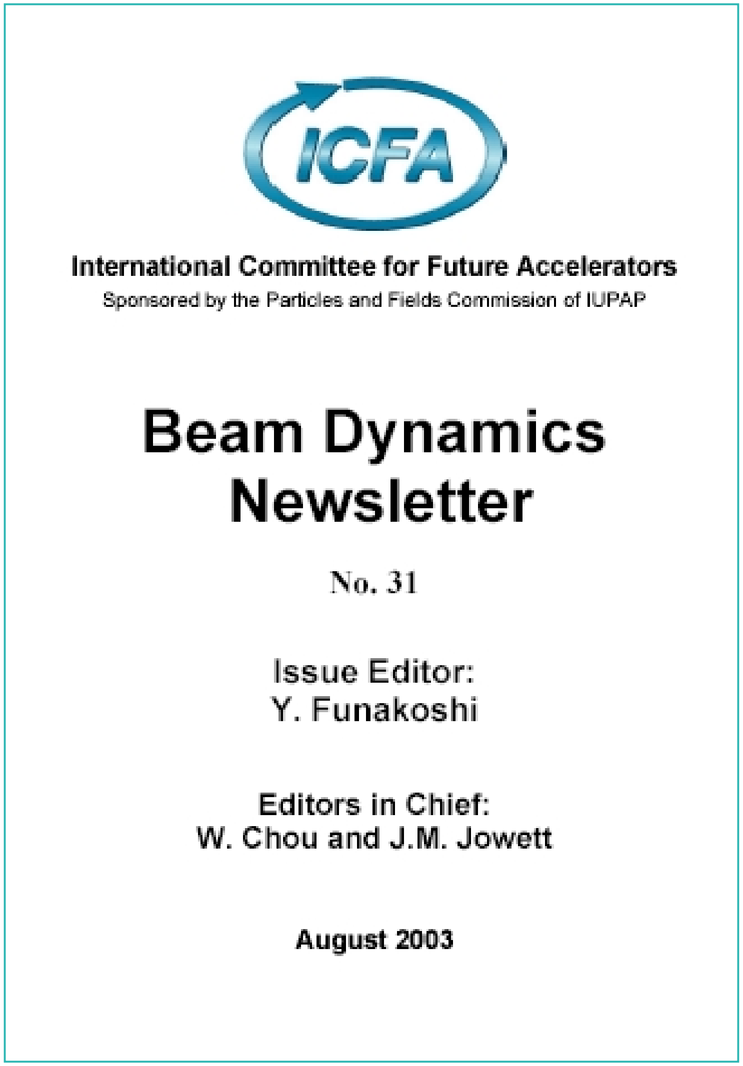
monochromators

…

30th Advanced ICFA Beam Dynamics Workshop on High Luminosity e+e- Collisions

October 13-16, 2003
Stanford, California

e+e- in the 1-2 GeV range: -
September 2003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Beam Dynamics Newsletter

No. 31

Issue Editor:
Y. Funakoshi

Editors in Chief:
W. Chou and J.M. Jowett

August 2003

Dedicated to:

HIGH LUMINOSITY E+ E- COLLIDERS

e+e- in the 1-2 GeV range: -
September 2003

CONCLUSIONS