Session Summary : Low Emittance Beam
Akira Mochihashi
Low Emittance Beam in SuperKEKB

- Presentor: Dr. K. Ohmi (KEK)

- X-Y coupling in low emittance ring
  - Global Coupling … Vertical emittance
  - Local Coupling … Vertical beam size

- How to correct X-Y coupling in SuperKEKB
  - By using correctors … measure beam orbit
  - Corrected by skew-Qs
X-y coupling correction in SuperKEKB

- Exciting 6 horizontal steerings one by one, measure closed orbit distortion in each.
- Vertical orbit is corrected by skew quads or vertical bump of sextupoles.

HER

LER

- \( r_1 \) and \( r_2 \) at every \( s \) is corrected, \( r_3 \) and \( r_4 \) are corrected as the result.
- X-y coupling in LER is somewhat worse than HER.
Vertical Emittance in Phase 2

- Emittance of HER is improved compared with Phase 1.
- Emittance of LER is larger than that of Phase 1.

Note: Residual of XY coupling is larger compared with Phase 1.

\[ \varepsilon_y \sim 23 \text{ pm} \quad \varepsilon_x = 3 \text{ nm} \]

\[ \varepsilon_y \sim 9 \text{ pm} \quad \varepsilon_x = 5 \text{ nm} \]
Low Emittance Operation in SuperKEKB

- To relax the beam-beam tune shift
- To keep the luminosity…

- Beta-squeezing has been performed.
Commissioning of SuperKEKB, Phase II

• \( \beta \) squeezing
5.55 x 10^{33} / cm^2/s (β_y*3mm, LER: 800mA, HER: 780mA, 1576 bunches/beam July 5th)
2.29 x 10^{33} / cm^2/s (β_y*3mm, LER: 270mA, HER: 225mA, 394 bunches/beam July 3rd)
Overview of IR magnets

- Compensation solenoids [ESL, ESR1, ESR2 and ESR3]

- In the left cryostat, one solenoid (12 small solenoids) is overlaid on QC1LP and QC1LE.
  - In the right cryostat, the 1st solenoid (15 small solenoids) is overlaid on QC1RP, QC1RE and QC2RP.
    - The 2nd and 3rd solenoids on the each beam line in the QC2RE vessel.

- Linear and nonlinear correction coils including skew are wound in QC1-2.
- R2 was corrected by a1 (skew Q) correction coil of QC1.
June 30, 2018

Observations

- 0 mA, $\sigma_y=0.25 \mu m$, $0.25 \mu m$, $L_{sp}=49$
- 200x160 mA, $\sigma_y=0.4 \mu m$, $0.6 \mu m$, $L_{sp}=24.4$
- 285x340 mA, $\sigma_y=0.6 \mu m$, $0.6 \mu m$, $L_{sp}=20.7$

$L_{sp}$ agrees with geo value at every current

$L_{peak}=2.5 \times 10^{33} \text{ cm}^{-2} \text{s}^{-1}$, (2 times higher)

285x340 mA, $N_b=788$

$L_{sp} = \frac{1}{2\pi \sigma_x \sigma_y e^2 f_0} 
10^{30} \text{ cm}^{-2} \text{s}^{-1}/\text{mA}^2$

$\sigma_y = \sqrt{\sigma_{y+}^2 + \sigma_{y-}^2}$

6/29 21:00 - R2 using QCS corrector

Blow-up of e+ beam was serious.
Dynamic Aperture and Momentum Acceptance in Low Emittance Storage Ring

- Presentor: Dr. A. Papash (KIT)

- Theoretical consideration and suggestion: how to get wide acceptance in low emittance storage ring
Difraction Limited Light Source (E. Levichev, BINP Proposals. 2013)

Figure 11: Five-cell superperiod with two horizontal sex-tupole pairs (denoted X) and two vertical ones (denoted Y).

DA of BINP DLLS ring (proposals)

\[ DA_{BINP} > \pm 20 \text{ mm} \]
\[ MA_{BINP} = \pm 1.5\% \]

Figure 13: Dynamic aperture of the 10 pm emittance storage ring at \( \beta_{s,y} = 10 \text{ m} \).

Figure 10: Split magnet TME cell for ultimate storage ring. A. Bogomyagkov, E. Levichev, P. Piminov. Proc. IPAC-2014.

\[ K_{Sx}L = +39 \text{ m}^{-2} \]
\[ K_{Sx}^{comp}L = -2.7 \text{ m}^{-2} \]

\[ K_{Sy}L = -94 \text{ m}^{-2} \]
\[ K_{Sy}^{comp}L = +8.4 \text{ m}^{-2} \]

On-momentum

On-momentum

Comparisoin of DLLS Projects

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<tr>
<th></th>
<th>MAX IV</th>
<th>ESRF Phase II</th>
<th>Spring-8</th>
<th>Diamond</th>
<th>ALS</th>
<th>Our proposal</th>
<th>Pep-X</th>
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<td>10 mm</td>
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Original table -- R.Bartolini. “Ultimate storage rings“. CLIC Workshop 2013. CERN.
Table taken from E.Levichev. „Difraction Limited electron storage ring with large DA“. BINP Proposals. 2013.

It is commonly recognized that Required DA for Light Sources to ensure beam injection

\[ DA_x \geq \pm 10 \text{ mm} \]

Momentum Acceptance should be

\[ MA = \frac{\Delta P}{P_0} \geq \pm (2\div4)\% \]

to provide reasonable Life time

\[ T_{1/2} \geq 10 \text{ hours} \]