Luminosity Tuning and Operation Statistics at KEKB

Manabu Tanaka
Mitsubishi Electric System & Service Co., Ltd

Yoshihiro Funakoshi
High Energy Accelerator Research Organization (KEK)
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Injection method

Before the continuous injection mode
Injection method

After the continuous injection mode
Injection method

The present simultaneous injection
Orbit correction at collision point

• Make a bump
  Near the interaction point (IP) of HER with steering magnets of HER

• Called “iBump feedback“.

• Best adjust
  → The difference of position (Offset) and angle (crossing angle) to 0
Orbit correction at collision point

- Offset and crossing angle in the vertical
  → Adjusted to 0

- Horizontal crossing angle (22 mrad)
  → No feedback

- The horizontal offset
  → Used two kinds of feedbacks
    Easy feedback & Beam Size feedback
Orbit correction at collision point

- Easy feedback
  Feedback to keep the ratio between the read value of a kick angle of a horizontal steering magnet and the height of horizontal bump.
Orbit correction at collision point

- Beam Size feedback
  Keep the LER beam size at some target value.

- The feedbacks for the horizontal offset are not used with the crab cavity.
  → Keep the beam-beam kick at some target value.
Knob tuning

3km

Orbit corrections of the rings
→ CCC (every 10s)

Only the collision point
→ iBump feedback (every 1s)
Knob tuning

- When changed knobs
  The orbits around the rings are distorted.
Knob tuning

By fitting the knob set vs. luminosity curve with a parabolic function
Knob tuning

Tuning Knobs

- **iBump feedback**
  
  The target value of the horizontal offset, the vertical offset, and the vertical crossing angle are adjusted to the best value.

- **Coupling, vertical dispersion**
  
  The x-y couplings and the vertical dispersion are important tuning knobs.
Knob tuning

Coupling and vertical dispersion tuning panel
Knob tuning

Tuning Knobs

• Waist
  The minimum position of the vertical beta function

• Betatron-tune
  Tune of Horizontal and Vertical
Knob tuning

Betatron-tune plot chart
Knob tuning

**Bunch Current Monitor**

**LER #Bunch:** 1585  
**Max:** 1.36 mA  
**Min:** 0.89 mA  
**Std:** 0.05 mA  
**Pilot:** 1.08 mA

**Bunch Current Monitor on 172.19.46.172:0.0**

**LER #Bunch:** 1538  
**Max:** 0.92 mA  
**Min:** 0.08 mA  
**Std:** 0.05 mA  
**Pilot:** 0.92 mA

**Bunch Current Monitor on 172.19.46.172:0.0**
Tuning Knobs

• Vertex Point
  The RF phase of LER is adjusted by the program.

• Chromaticity
  SX is adjusted and to extend beam life.
Knob tuning

Downhill Simplex Method

Method of Minimization
• \( \{1, 2, 3\} \) \( 1 \) (best) \(<\) 2 (next-to-the worst) \(<\) 3 (worst)
• Evaluate \( 3_R \)
  • If \( 3_R < 1 \),
    • If \( 3_E < 3_R \), \( \{1, 2, 3_E\} \) : Expand, if not, \( \{1, 2, 3_R\} \) : Reflect
  • If \( 1 < 3_R < 2 \), \( \{1, 2, 3_R\} \) : Reflect
  • If \( 2 < 3_R < 3 \),
    • If \( 3_{c+} < 3_R \), \( \{1, 2, 3_{c+}\} \) : Contract+, if not, \( \{1, 2, 3_R\} \) : Reflect
  • If \( 3 < 3_R \),
    • If \( 3_{c-} < 3 \), \( \{1, 2, 3_{c-}\} \) : Contract−, if not, \( \{1, 2_{s}, 3_{s}\} \) : Shrink
Knob tuning

Downhill Simplex Method
Knob tuning

Knob scanning by DSM

Luminosity ↑
Knob tuning

Movement of knobs at DSM
Crab cavities
Crab cavities

Head-on collision
Crab cavities

KEKB operation with crab cavities

mA

/ nb/s

Before

After

May, 2009

HER

LER

Peak Luminosity
Crab cavities

• Why HER beam current was able to be increased?

1. The aperture was extended near the LER crab cavities by the Optics change.

2. The $\beta_x$ in the collision point was loosened.
Skew sextupole magnets
Skew sextupole magnets

![Graph showing data related to luminosity and beam current](graph.png)
Operation period

WAO10 2010/04

Chart showing the operation period from 2002 to 2009, with bars representing days and a line graph representing hours.
Operation period

The operation time and contents

![Bar chart showing operation period from 2002 to 2009 with different categories such as Others, Maintenance, Trouble, Beam Tuning, Machine Tuning, Machine Study, and Physics Run.]
Operation period

The operation utilization rates

Fiscal Year

2002 2003 2004 2005 2006 2007 2008 2009

Others
Maintenance
Trouble
Beam Tuning
Machine Tuning
Machine Study
Physics Run
Integrated and peak Luminosity

Fiscal Year

Annual Integrated Luminosity

Averaged Daily Luminosity

( fb )

( fb/day )

1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Acknowledgements
Thank you
Spare slides
Knob tuning

Bunch Current Monitor
Detail content of operation in 2009

- Physics Run: 78%
- Machine Tuning: 7%
- Beam Tuning: 4%
- Trouble: 2%
- Maintenance: 2%
- Others: 0%
- Machine Study: 7%
Operation period

Detail content of operation in 2008

- Physics Run: 72%
- Machine Study: 10%
- Machine Tuning: 2%
- Beam Tuning: 9%
- Machine Study: 10%
- Maintenance: 3%
- Trouble: 4%
- Others: 0%
Beam abort

HER Weekly Abort 2004/10 ~ 2008/12

- RF
- BeamLoss
- EQ
- Vac
- Mag
- Other
- Not Ready
- Crab

Date vs. Number of aborts
Beam abort

LER Weekly Abort 2004/10 ~ 2008/12

- RF
- BeamLoss
- EQ
- Vac
- Mag
- Other
- Not Ready
- Crab
Beam abort

Before Crab Operation

Crab Operation

HER Weekly Abort 2004/10 ~ 2008/12
Beam abort

Before Crab Operation

Crab Operation

LER Weekly Abort  2004/10 ~  2008/12
Beam abort

HER & LER Crab Abort 2004/10 ~ 2008/12

Date

Number of aborts

07/1  07/3  07/5  07/7  07/9  07/11  08/1  08/3  08/5  08/7  08/9  08/11  09/1

0  10  20  30  40

HER Crab
LER Crab
Breakdown time

Transition of the trouble according to fiscal year

(Fiscal Year)

(Hour)

2002 2003 2004 2005 2006 2007 2008

Others Refrigerator LINAC Belle BM Control Facilities Safety RF BT Magnets Vacuum
Breakdown time

Trouble details in fiscal year 2008

- **Vacuum**: 25%
- **Magnets**: 11%
- **BT**: 7%
- **Others**: 19%
- **Belle**: 10%
- **Control**: 1%
- **BM**: 1%
- **Facilities**: 0%
- **Safety**: 0%
- **LINAC**: 2%
- **Refrigerator**: 0%
- **RF**: 24%
- **BT**: 7%
Breakdown time

Trouble details in fiscal year 2009

- Vacuum: 10%
- BT: 35%
- Magnets: 8%
- Others: 1%
- Belle: 2%
- Control: 0%
- BM: 0%
- Facilities: 0%
- LINAC: 4%
- Refrigerator: 13%

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