Karlsruhe Institute of Technology

# Session Summary : Low Emittance Beam

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# Low Emittance Beam in SuperKEKB

- Presentor: Dr. K. Ohmi (KEK)

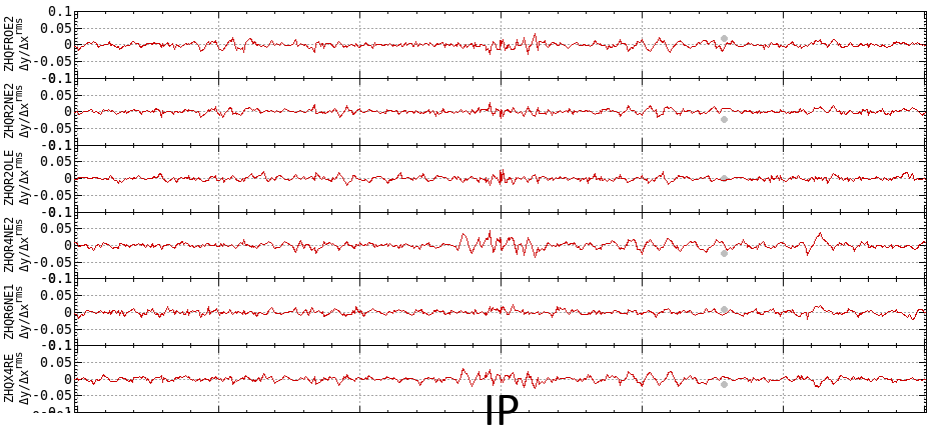
- X-Y coupling in low emmittance ring
  - Global Coupling … Vrtical emittance
  - Local Couplling … Vertical beam size

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

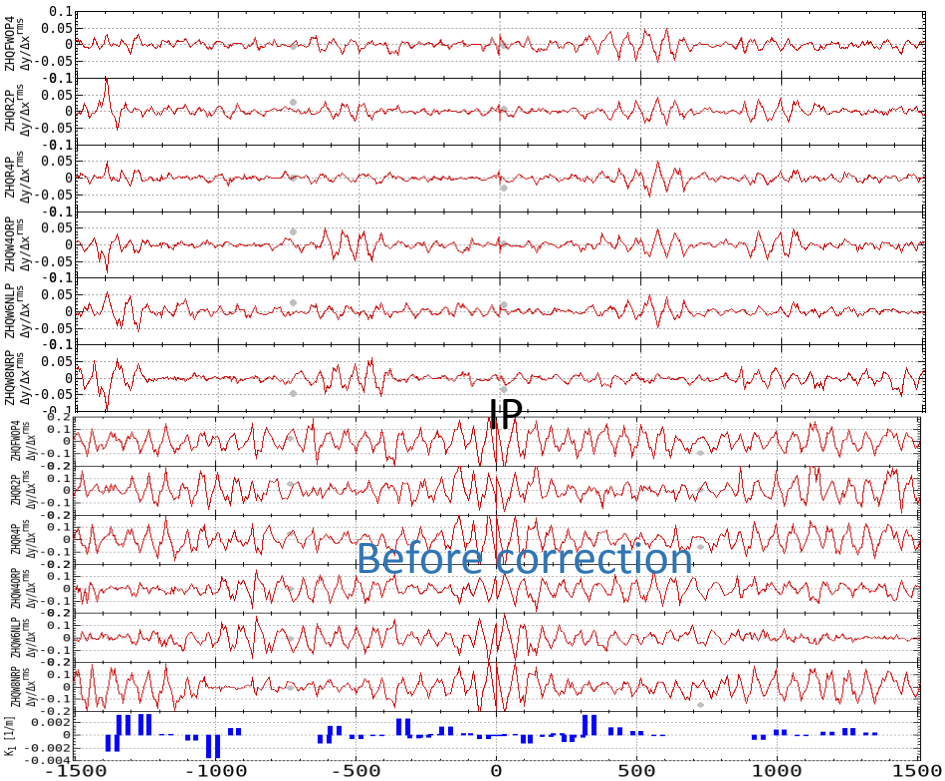
# X-y coupling correction in SuperKEKB

- 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



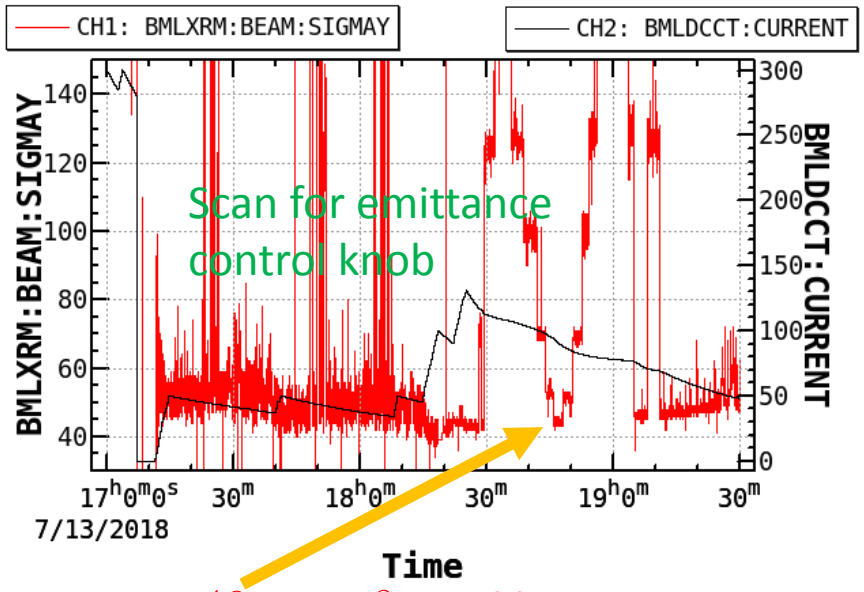

LER




- r1 and r2 at every s is corrected, r3 and r4 are corrected as the result.
- X-y coupling in LER is somewhat worse than HER.

# Vertical Emittance in Phase 2

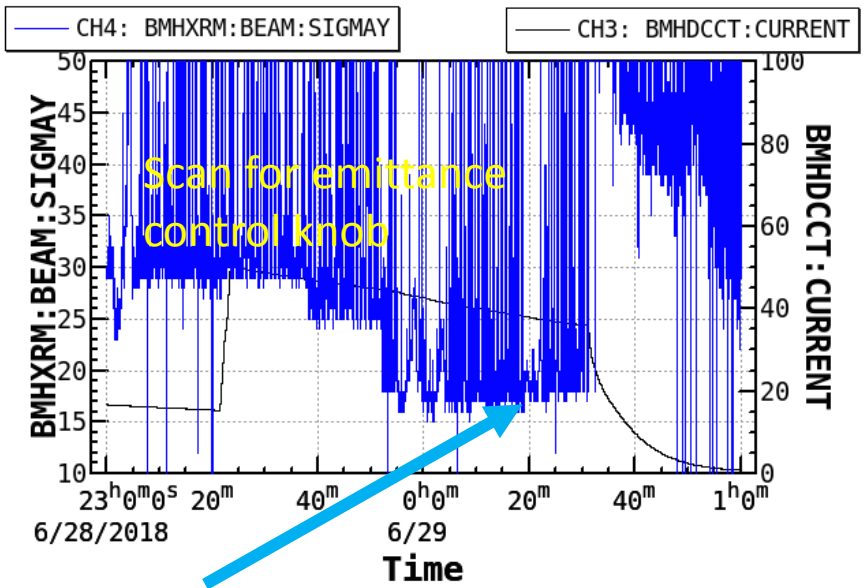
**LER**




$\sigma_y = 40\ \mu\mathrm{m}\ \ \beta_y = 69\ \mathrm{m}$

$\varepsilon_y \sim 23\ \mathrm{pm}$ $\quad \varepsilon_x = 3nm$

**HER**




$\sigma_y = 16\ \mu\mathrm{m}\ \ \beta_y = 28\ \mathrm{m}$

$\varepsilon_y \sim 9\ \mathrm{pm}$

$\varepsilon_x = 5nm$

- Emittance of HER is improved compare with Phase 1.
- Emittance of LER is larger than that of Phase 1.
  Note: Residual of XY coupling is larger compare with Phase1.

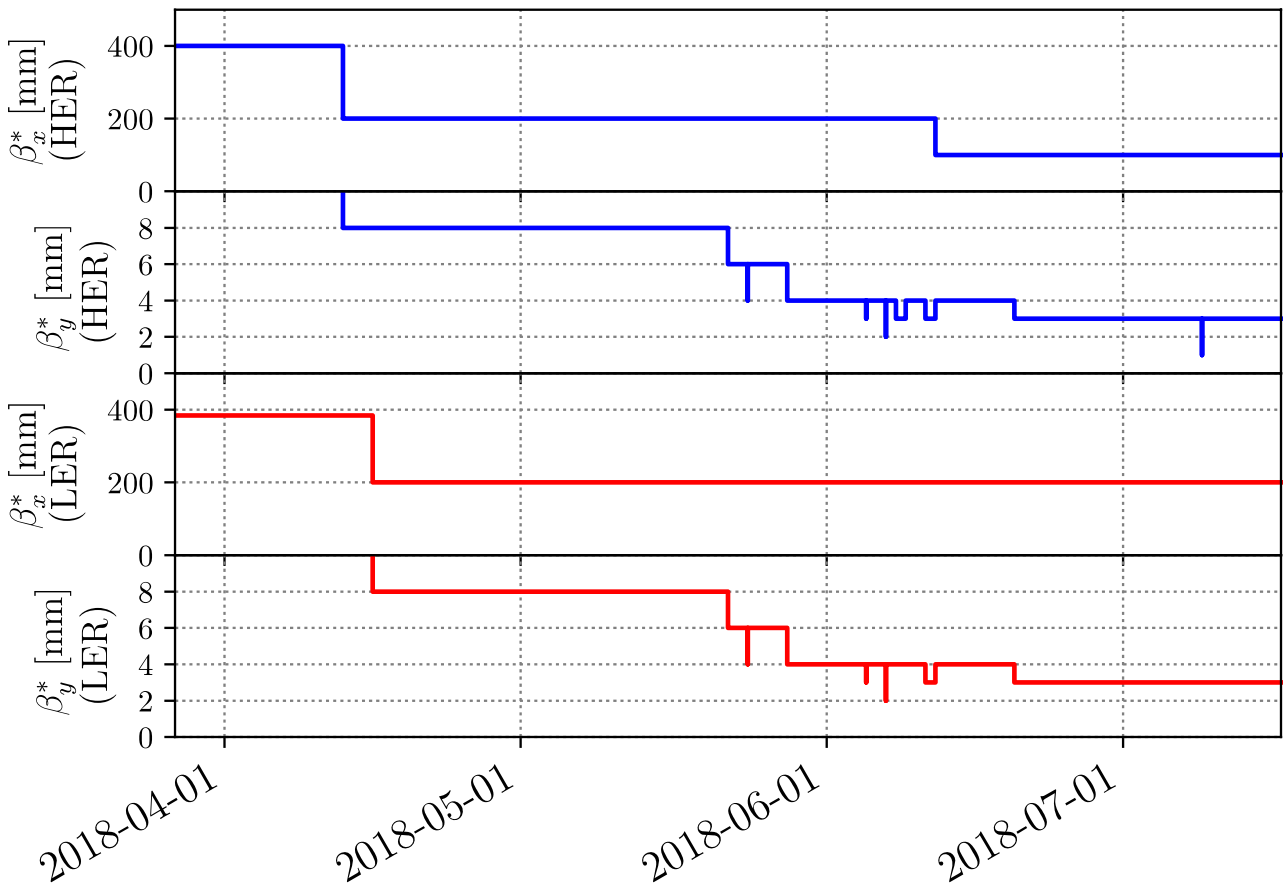
# Low Emittance Operation in SuperKEKB

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

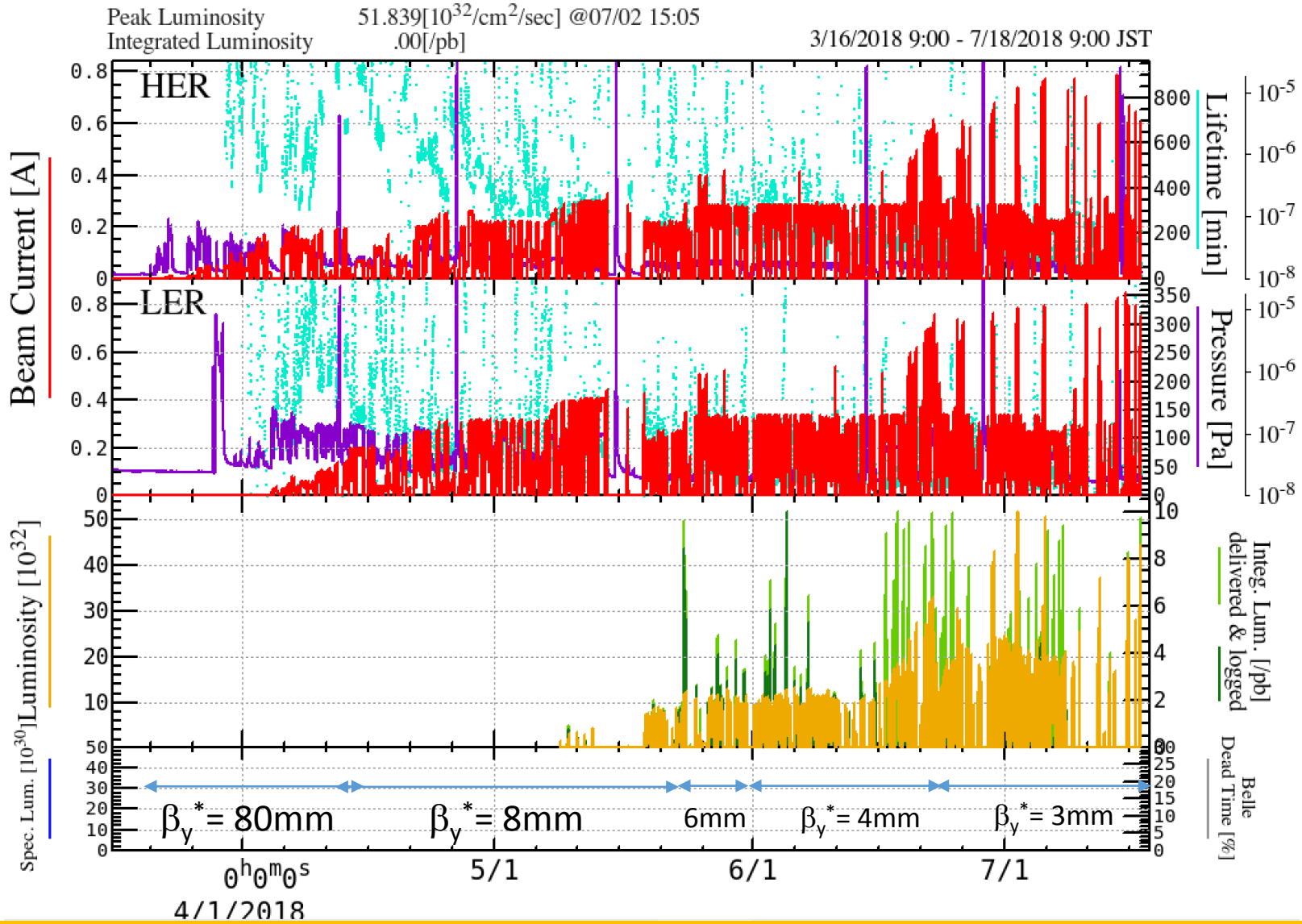
- Beta-squeezing has been performed.

# Commissioning of SuperKEKB, Phase II

- β squeezing



# History of SuperKEKB Phase 2



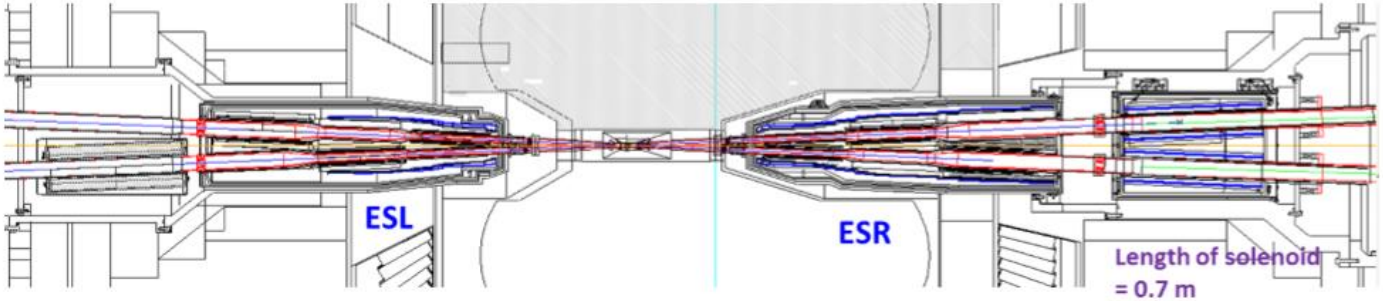

5.55 x $10^{33}$/cm$^2$/s (βy*3mm, LER: 800mA, HER: 780mA, 1576 bunches/beam July 5th)

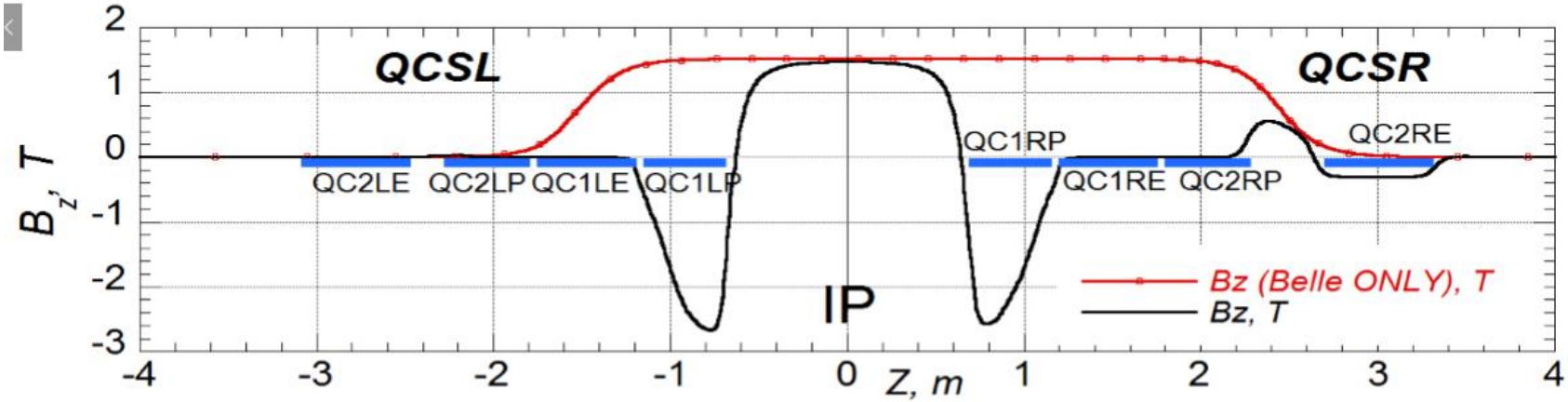
2.29 x $10^{33}$/cm$^2$/s (βy*3mm, LER: 270mA, HER: 225mA, 394 bunches/beam July 3rd)

# Overview of IR magnets

N. Ohuchi et al.

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



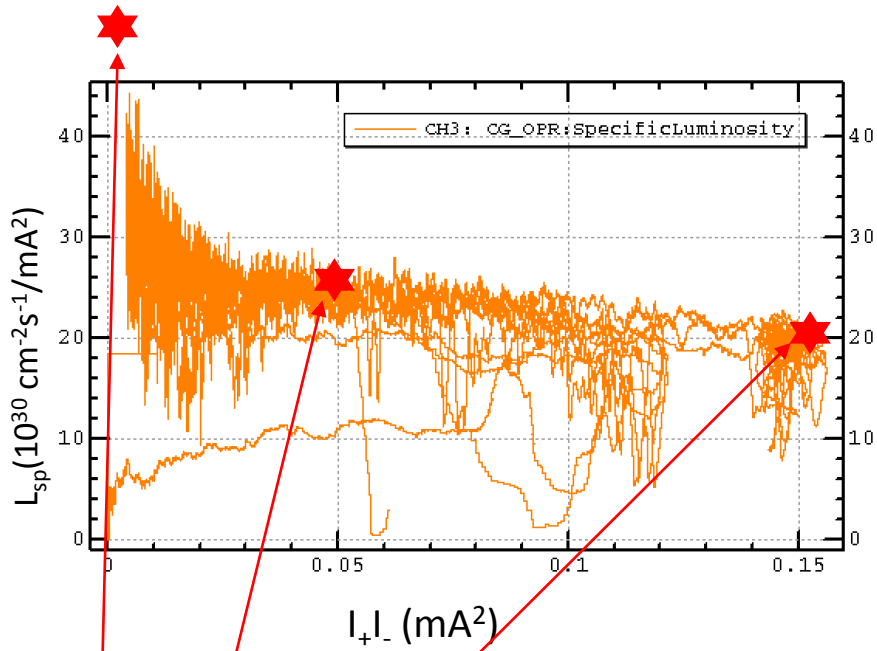

- In the left cryostat, one solenoid (12 small solenoids) is overlaid on QC1LP and QC1LE.
- In the right cryostat, the 1st solenoid (15 small solenoids) is overlaid on QC1RP, QC1RE and QC2RP.
  - The 2nd and 3rd solenoids on the each beam line in the QC2RE vessel.

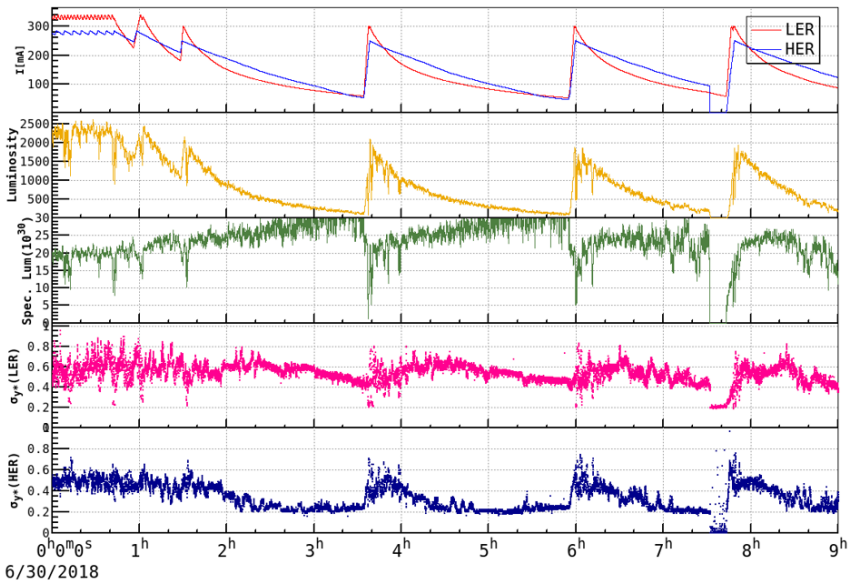


- Linear and nonlinear correction coils including skew are wound in QC1-2.
- R2 was corrected by a1 (skew Q) correction coil of QC1.

# June 30, 2018

## Observations




$$L_{sp} = \frac{1}{2\pi\sigma_{xc}\sigma_{yc}e^2 f_0}$$

$10^{30}$ cm$^{-2}$s$^{-1}$/mA$^2$

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

- 0mA, $\sigma_{y0}$=0.25μm, 0.25μm, Lsp=49
- 200x160mA, $\sigma_{y0}$=0.4μm, 0.6μm, Lsp=24.4
- 285x340mA, $\sigma_{y0}$=0.6μm, 0.6μm, Lsp=20.7

Lsp agrees with geo value at every current

6/29 21:00- R2 using QCS corrector

$L_{peak}$=2.5x10$^{33}$ cm$^{-2}$s$^{-1}$ , (2 times higher)

285x340mA, $N_b$=788

Blow-up of e+ beam was serious.

# Dynamic Aperture and MomentumAcceptance in Low Emittance Storage Ring

- Presentor: Dr. A. Papash (KIT)

- Theoretical consideration and suggestion: how tp get wide acceptance in low emittance storage ring

# Difraction Limited Light Source (E.Levichev. BINP Proposals. 2013)

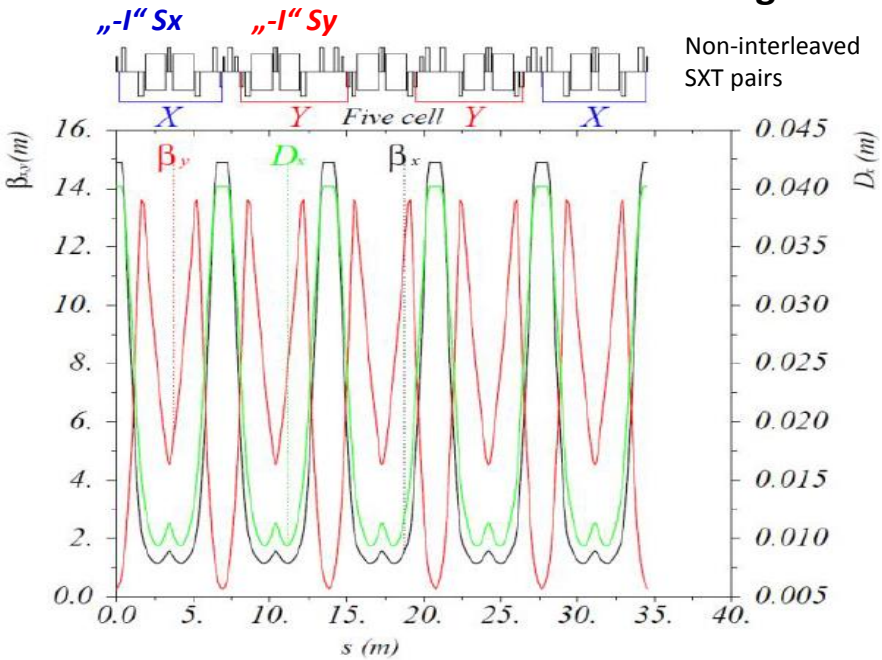



Figure 11: Five-cell superperiod with two horizontal sextupole pairs (denoted X) and two vertical ones (denoted Y).

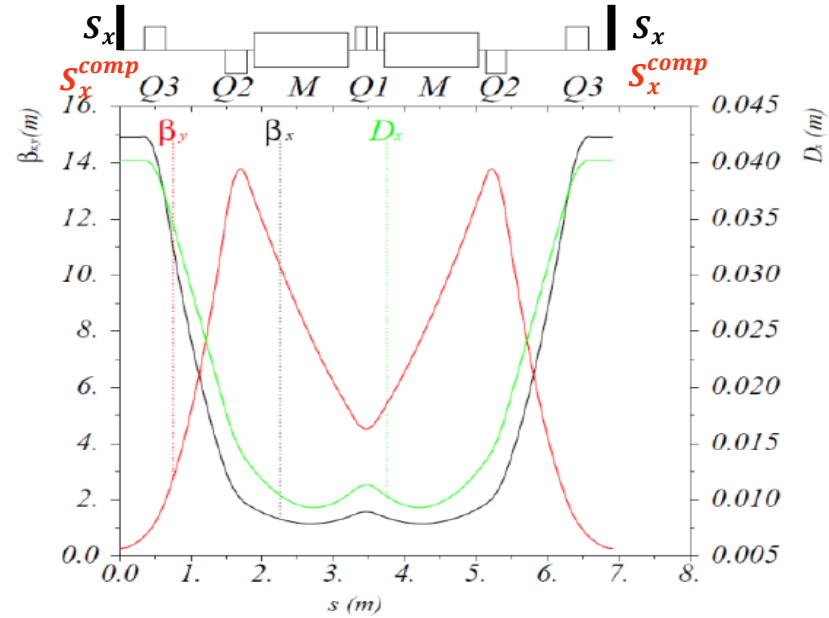



Figure 10: Split magnet TME cell for ultimate storage ring.

A.Bogomyagkov, E.Levichev, P.Piminov. Proc. IPAC-2014.

**DA of BINP DLLS ring (proposals)**

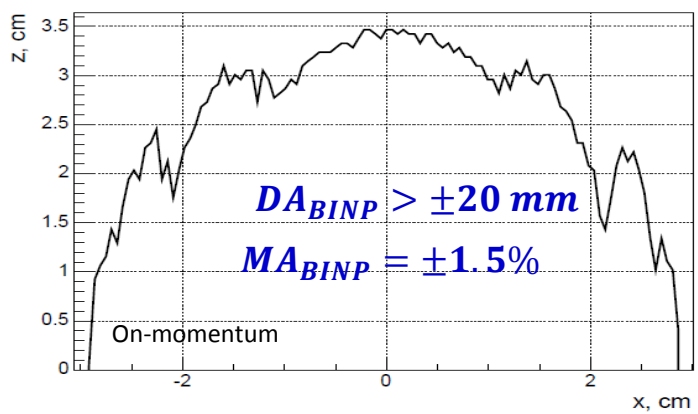
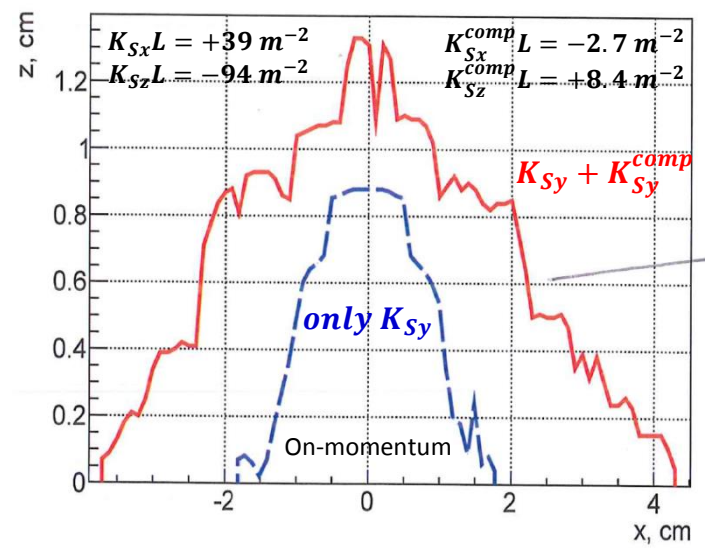



Figure 13: Dynamic aperture of the 10 pm emittance storage ring at $\beta_{x,y} = 10$ m.




E.Levichev. „Difraction Limited electron storage ring with large DA“. BINP Proposals. 2013.

# Comparisoin of DLLS Projects

| | | | | | | |
|---|---|---|---|---|---|---|
| MAX IV | 7BA | 3 GeV | 528 m | 320 pm | 500 mA | DA 20 mm |
| ESRF Phase II | 7BA | 6 | 850 | 130 | 200 | 10 mm |
| Spring-8 | 6BA | 6 | 1400 | 67.5 | 300 | 3 mm |
| Diamond | 4-5-7BA | 3 | 560 | 45-300 | 300 | 2 mm |
| ALS | 5 -7BA | 2 | 200 | 50-100 | 500 | 2-3 mm |
| **Our proposal** | **7BA** | **3** | **1300** | **15** | **200** | **40 mm** |
| Pep-X | 7BA | 4.5 | 2200 | 11 | 200 | 10 mm |
| tUSR | 7BA | 9 | 6200 | 3 | 100 | 0.8 mm |

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**

$$DA_X \geq \pm 10\ mm$$

**Momentum Acceptance should be** $MA = \frac{\delta P}{P_0} \geq \pm\,(2 \div 4)\%$

**to provide reasonable Life time** $T_{1/2} \geq 10\ hours$