

## Followup to

# **Modeling of Electron Cloud Buildup in the Final-focus Quadrupole**

# **Magnets of the SuperKEKB Positron Ring**

(-- Updated/corrected following meeting --)

(see Electron Cloud/Impedance meeting talk of 4/22/2015)

-- Request from K. Ohmi at IPAC15 for pictures of cloud distributions --



Jim Crittenden Electron Cloud/Impedance Meeting 27 May 2015





### SuperKEKB Interaction Region (Y. Arimoto et al, IPAC14, WEPRI086)



The BELLE-II solenoid is offset by 470 mm relative to the IP in the flight direction of the 7-GeV electron beam. The final-focus quadrupole QC1RP for the 4-GeV positron beam is in the region of uniform solenoid field.

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#### SuperKEKB Interaction Region Solenoid and quadrupole magnetic fields



**Final-focus Quadrupole Magnets for the 4 GeV Positron Beam** 

QC2RP: 0.410 m 28 T/m

QC1RP:) 0.334 m 69 T/m

QC2LP: 0.410 m 28 T/m

QC1LP: 0.334 m 69 T/m

The combined BELLE-II detector solenoid and compensation solenoid fields produce a field which varies along the length of QC1RP, ranging from about 0.6 T to about 2.6 T. The direction of the field is rotated 83/2 mrad relative to the positron beam axis.



**Electron cloud buildup results with and without** quadrupole and solenoidal magnetic fields



Such electron cloud densities are 3-4 orders of magnitude higher than the ring average estimated by the KEK vacuum group.

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**Snapshots of transverse cloud distribution** (Vacuum chamber diameter 21 mm. Unconditioned copper surface.)

$$B' = 69 T/m$$
  $B_z = 2 T$ 





The quadrupole symmetry is broken by the rotated longitudinal magnetic field. The magnetic fields causes hot spots near the top of the chamber. With no magnetic field there are hot spots near the sides of the chamber. The hot spots are a factor of six more dense with the magnetic field, reaching more than 2.5x10<sup>9</sup> electrons in one 1-mm by 1-mm bin. The overall cloud density is a factor of three higher.



Large electric field gradients ==> large tune shifts Factor >15 larger than Ohmi estimate at IPAC14



Fractional tune shift =  $\Delta L^* dE_V/dY * \beta_V/(4\pi E/eV) = 2.0e-8 dE_V/dY (V/m^2) = 0.016$ ( $\beta_V = 3000 \text{ m !}$ )

Ohmi found a maximum value of 0.001 for excluding ±30 m around the IP (TUPRI020, IPAC14). During a private discussion at IPAC15, SuperKEKB commissioning group leader Funakoshi estimated the beam-beam tune shift in design conditions to be about 0.05.

No electron cloud production in the final-focus quadrupoles was taken into account, since no photon scattering simulation had been done.

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#### Yoshihiro Funakoshi Commissioning Group Leader





Kazuhito Ohmi Simulation Group Leader



#### **Effect of magnetic fields on the tune shifts** (Unconditioned copper surface)



The off-axis solenoidal field causes the high field gradients at the beam. The additional quadrupole field reduces the gradients.

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**Snapshots of transvers cloud distribution** (Vacuum chamber diameter 21 mm. Unconditioned copper surface.)

$$B' = 69 T/m$$
  $B_z = 0 T$ 

B' = 0 T/m  $B_z = 2 T$ 



The quadrupole symmetry is restored when the rotated solenoid compensation field is removed.

The rotated solenoidal field causes high cloud densities and electric field gradients at the beam in both planes.



**Transverse cloud distributions averaged over the full simulation time of 438 ns** (Density (e/m<sup>3</sup>) in 0.5 × 0.5 mm bins)



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### All questions, comments and suggestions are welcome.

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Followup to SuperKEKB IR Quad Electron Cloud Modeling at IPAC15 / J.A.Crittenden

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