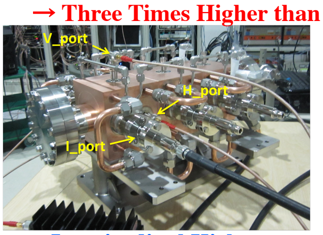
DEVELOPMENT OF A HIGHLY EFFICIENT ENERGY KICKER FOR LONGITUDINAL BUNCH-BY-BUNCH FEEDBACK

M. Masaki, T. Fujita, K. Kobayashi, T. Nakamura, M. Oishi, H. Ohkuma, S. Sasaki, M. Shoji

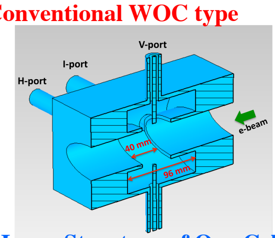
Japan Synchrotron Radiation Research Institute （JASRI/SPring-8）

Highly Efficient New Energy Kicker

Originally Designed and Developed Kicker in SPring-8
High Kick Efficiency per Length
→ Three Times Higher than Conventional WOC type



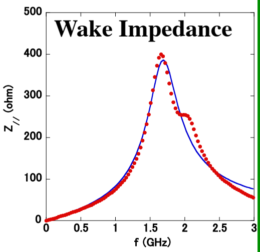
Longitudinal Kicker



Inner Structure of One Cell

3-cell Structure
Three Kicker Cells are embedded in the vacuum chamber.
Kicker Cell
Cavity Length 96 mm, Electrode Gap 40 mm
Driving RF Frequency
(3+1/4) f_{RF} = 1.65 GHz RF reference frequency f_{RF} = 508.58 MHz
Beam is kicked by a Single Resonant Mode excited at the driving frequency.

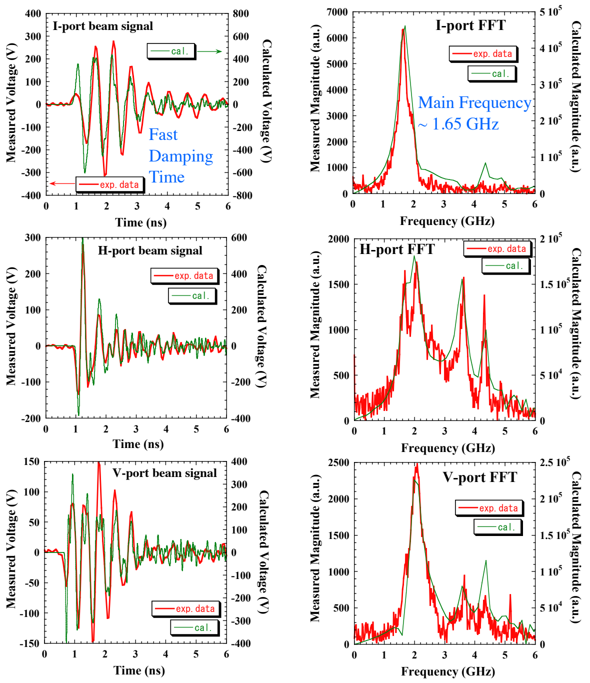
Low Q-factor
The resonant mode is required to have low Q-factor, i.e. fast damping time of several nanoseconds.
Longitudinal Wake Impedance (Calculation)
Assuming bunch length of 6mm (r.m.s.)
Estimated Q-factor by Lorentzian fitting
Q ~ 4.2



Driving RF Power
Input from symmetrically attached two I-ports at the same timing
Removal of Unwanted Higher Order Modes
Removed from two pairs of ports (H-ports, V-ports) attached symmetrically.
Cooling
Kicker body made of Copper with high thermal conductivity
Water-cooled copper body and high power feed-through ports (I-port)

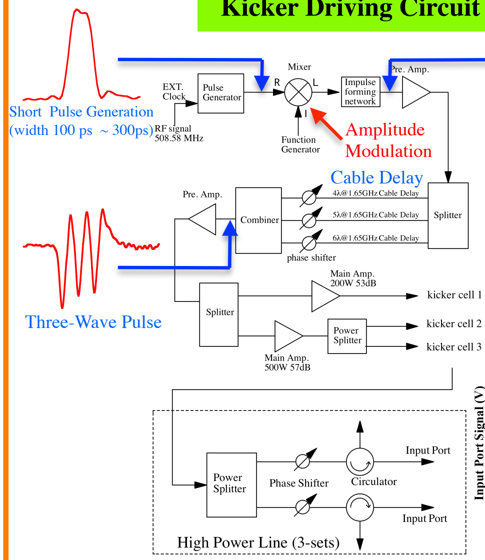
Response to a Single Bunch Beam

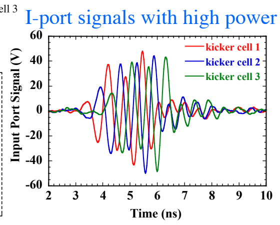
Beam signals observed at each port (I-port, H-port and V-port)
Observed signal waveforms have similar shapes to simulated results.



Beam Kick Test & Kick Performance

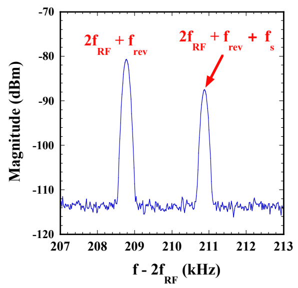
Kicker Driving Circuit



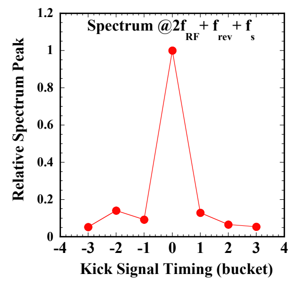


Electron bunches are kicked by using resonance of the synchrotron oscillation. Kick voltage was amplitude-modulated with f_{rev}+ f_s.

Bunch Fill Pattern : 84 bunches equal spacing (57 ns interval)
Mod. Freq. : f_{rev} (208.8 kHz @Revolution) +f_s (2.14 kHz @Synch. Osc.)

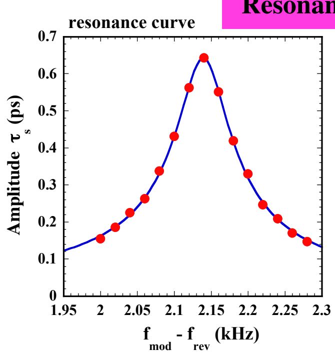


Observed Spectrum of Excited Synchrotron Oscillation



Residual Kicks to electron bunches in the adjacent RF buckets → 1/10 ~ 1/20

Resonance Curve



$$\tau_s = \frac{\dfrac{\alpha_c}{T_0}\dfrac{eV_{kick}}{E_0}}{\sqrt{\left(\omega^2-\omega_s^2\right)^2+\dfrac{4}{\tau_d^2}\omega^2}}$$

$\tau_{s,max}$ = 0.64 ps
V_{kick} = 920 V / 3kickers
f_s = 2.14 kHz
τ_d = 4.5 ms

Input Power per each kicker cell
$P_w = 2*(V_{peak}{}^2/50/2)$ ~ 44 (W/kicker)
Shunt Impedance per one cell
$R_s = (V_{kick}/3)^2/P_w/2 = (920/3)^2/44/2$ = **1.1 (kΩ)**

Shunt impedance per unit length is three times larger than that of waveguide overloaded cavity (WOC) type kicker.