Collective Effects in the SPring-8 Storage Ring

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SPring-8

Goal: 10OmA (multi-bunch), 5mA / bunch =>1.5mA/bunch

Multi-Bunch

Vertical Coupled-Bunch Instability
<- Resistive-Wall Impedance of In-Vacuum Undulators
Horizontal Coupled-Bunch Instability
<- Higher Order Modes of Acceleration Cavities
Longitudinal Instability at fs ([μ=0 mode)
<- Acceleration Voltage Amplitude Feed-Back
Bunch Volume Increase? at full-bunch operation ~ 100mA
Ion?

Single-Bunch

<- Broad-Band Impedance of Beam Pipe
Vacuum Pressure Rise
RF shock by High Peak Current
Ageing

Transverse Mode-Coupling Instability (m=0 and m=-1)
Positive Chromaticity ~0

Head-Tail Instability (m=0)
Negative Chromaticity

Bunch-Lengthening
Potential-Well Distortion by Inductive Impedance

Single-Bunch

Driven by

Broad-Band Impedance (bellows, cavities, small gaps,..)

Vacuum Pressure Rise → Limit Max. Bunch Current

Heating

High Electromagnetic Field by High Charge Bunch

Aging → Getting lower out-gas

Bunch Lengthening (Potential-Well Distortion)

Inductive Impedance is dominant (Estimated)

Energy Spread Increase Ith ~ 5mA/bunch

Vertical Instability

Chromaticity

$\xi y = -2$	Ith ~ 0.5 mA	Head-Tail m=0
$\xi y = 0.24$	Ith ~ 3 mA	Mode-Coupling m=0 & - 1
$\xi y > 4$	Ith > 15 mA	Stable

Simulation Study → Good agreement at Ib < 5mA

Simulation Code: SISR developed at SPring-8

Impedance

Calculated Wake (σz = Imm wake)

Estimated by simulation with MAFIA

Old version: fitting to model wake

Amplitude Dependent Tune Shift

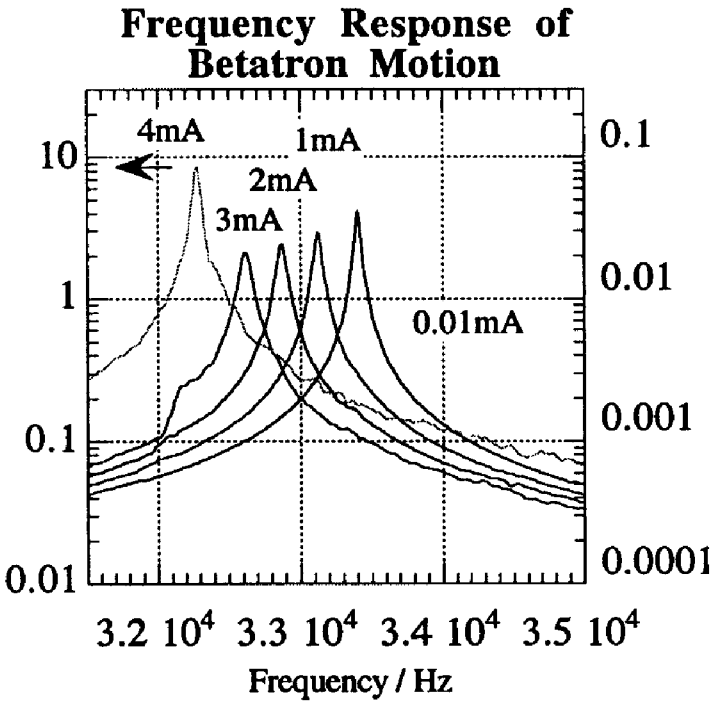
Saturation of Growth β

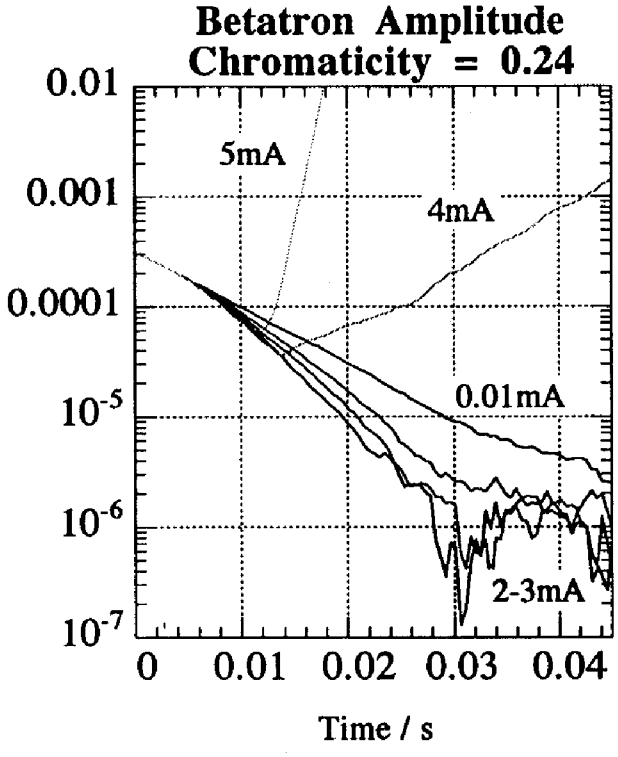
Nominal Vertical Chromaticity ~ 6

No instability Observed (Multi, Single)

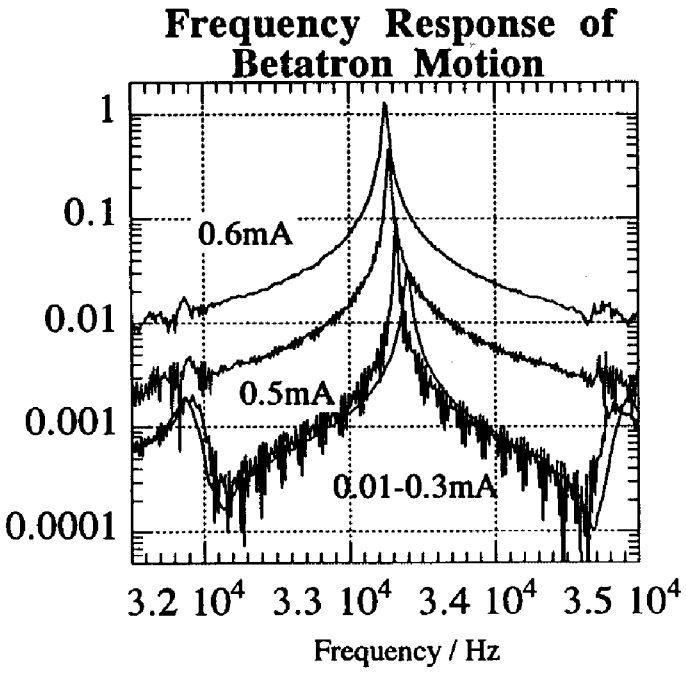
Betatron Motion (Simulation)

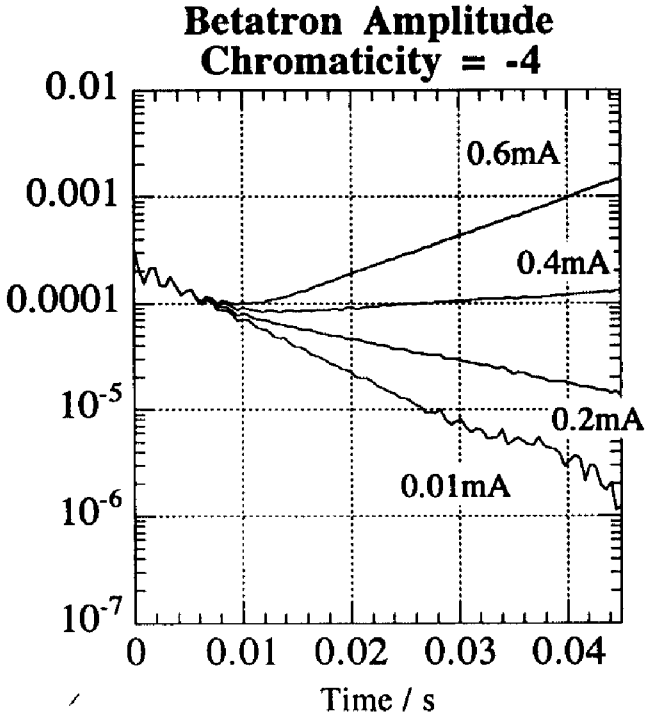
Chromaticity = 0.24
Mode-Coupling Instability



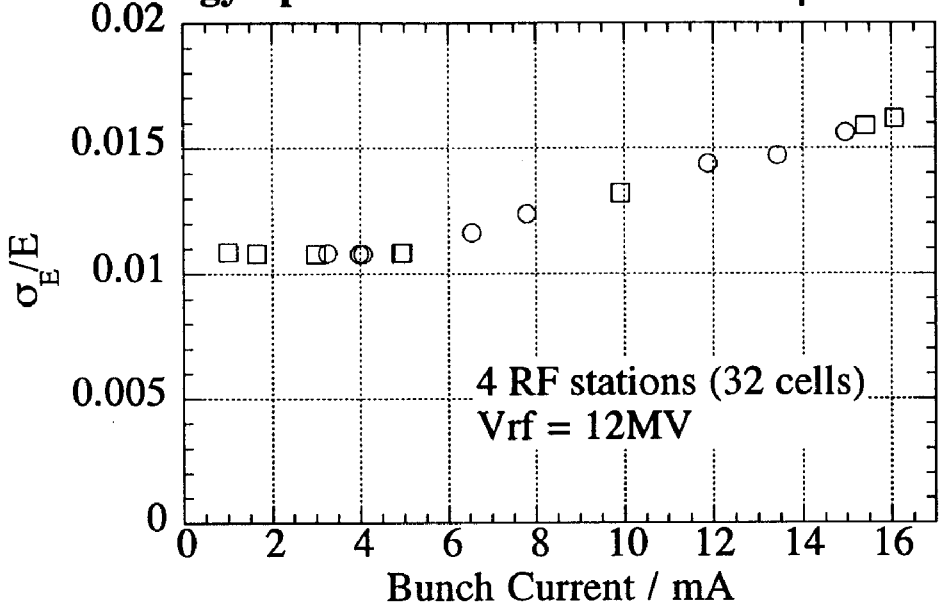


Chromaticity = -4
m=0 Head-Tail Instability

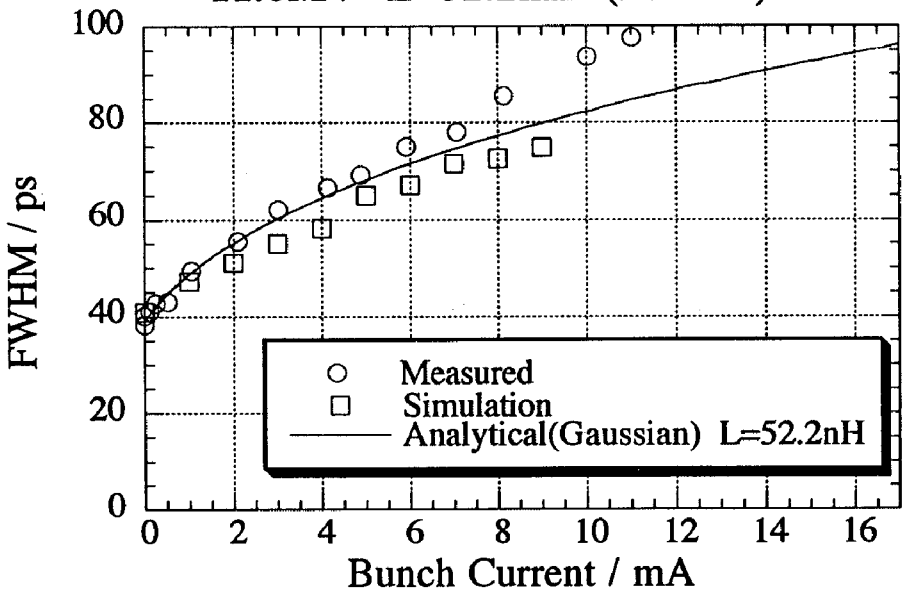




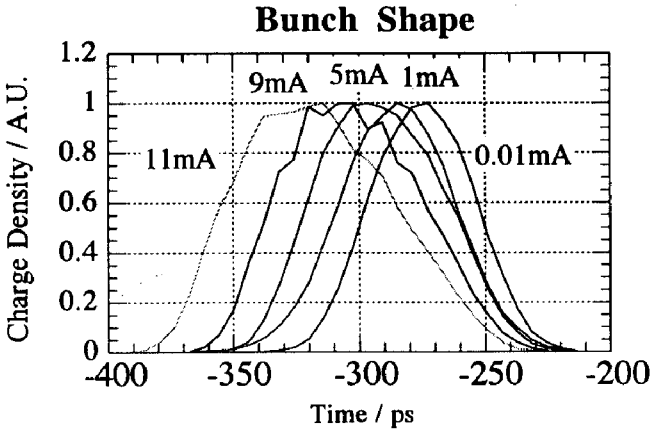
Energy spread from beam size @ η = 105mm



Potential-Well Distortion by Inductance
11.6MV L=52.2nH (981105)

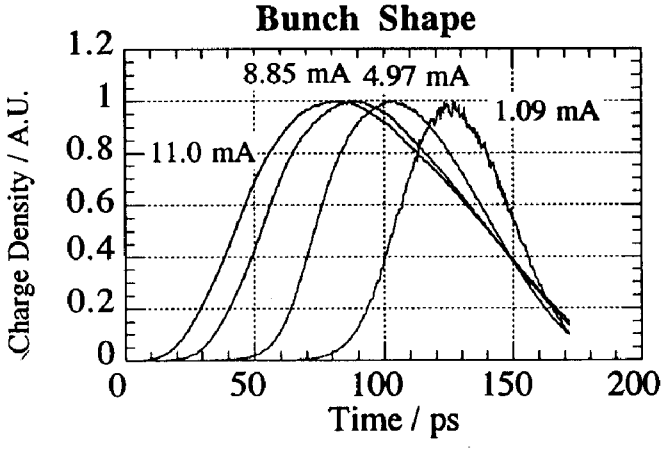


Bunch Shape



Simulation

Bunch Shape



Measured

Chromaticity = 3.7