Bunch Compression and Stretching using Barrier RF System
(Simulations and Experiments)

Chandra Bhat

Fermi National Accelerator Laboratory

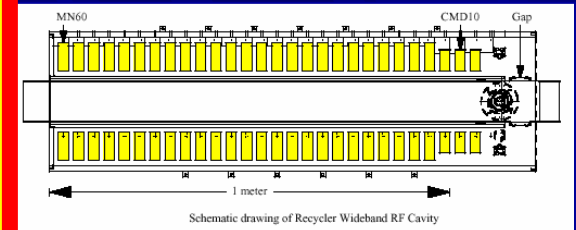RPIA 2006, KEK, Tsukuba, Japan
March 7-10, 2006

Recent Wide-band RF Systems

Barrier Cavities in the Recycler

Peak Voltage: 500V Power: 3.5kW

Type of Ferrite: Ceramic Magnetics MN60, CMD10

Shunt Impedance: 50 Ω /cavity

Band Width : 10kHz -100MHz

Dimension: ~ 1 meter

Cost: $75 k

Amplifier : Amplifier Research Model 3500A100

Cost: $150 k

PAC1999, p 869

MN60   CMD10   Gap

1 meter

Schematic drawing of Recycler Wideband RF Cavity

Peak RF Voltage: 500V

Type of Ferrite: Not Known

Shunt Impedance: 50Ω

Bandwidth ~50kHz-100MHz

Dimension= 1.5meter

Cost = not known

Test Device in MI

Main Injector Damper Cavities

Peak Voltage: 500V Power: 3.5kW

Type of Ferrite: 5 NiZn & 17MnZn Ferrite

Shunt Impedance: 50 Ω /cavity

Band Width : 10kHz -100MHz

Dimension: ~ 1 meter Cost: $75 k

Amplifier : Amplifier Research Model 3500A100

Cost: $150 k

D. Wildman

(private communications 2003)

Main Injector Barrier Cavity

Peak Voltage: 10kV Power: 150kW

Type of Ferrite: 7 Finemet ® cores

Shunt Impedance: 500 Ω /cavity

Band Width : 50kHz -100MHz

Dimension: ~ 0.75meter Cost: $75 k

Amplifier : Switch
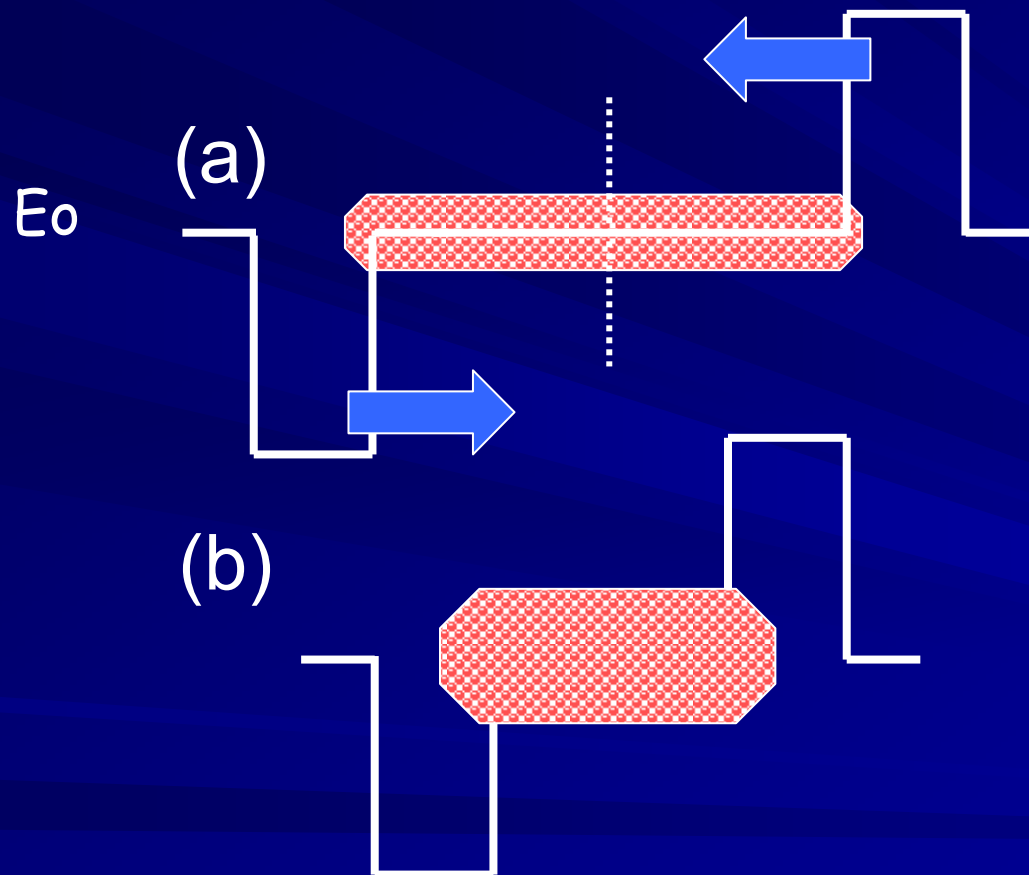
Cost: $40 k

D. Wildman

(private communications 2003)

Chandra Bhat

2

Iso-adiabatic Bunch Compression

(D. Wildman, C. Bhat, W. Chou .)
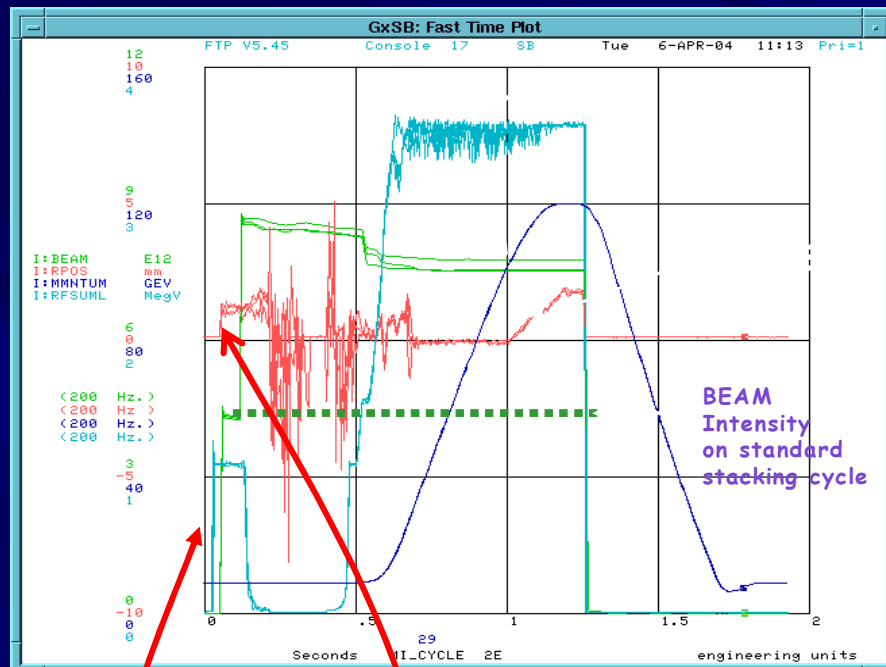
(a)

E_0

(b)

Concept: Inject a bunch into stationary barrier bucket. Compress the beam iso-adiabatically & symmetrically (or non-symmetrically) to the required size.
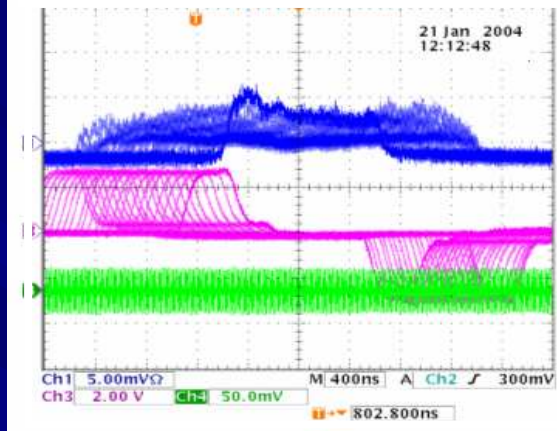
Bunch Compression in the Main Injector
D. Wildman, C.M. Bhat and W. Chou

GxSB: Fast Time Plot

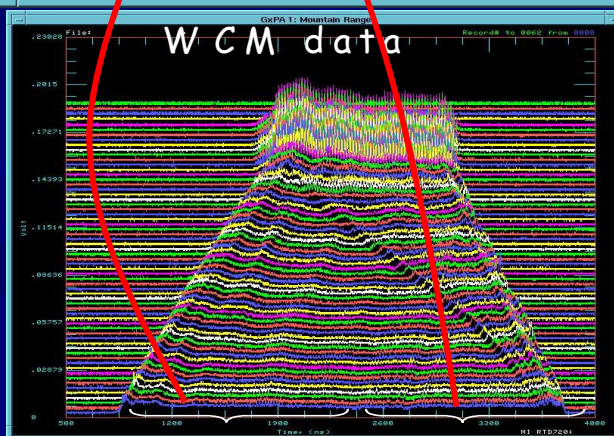**Cavity fanback signals and WCM data**

Barrier pulse = 5kV

BEAM Intensity on standard stacking cycle

WCM data

Compression time ~200 ms

Batch 1   Batch 2

RPIA 2006, March 7-10, 2006

Parameters:
Beam Intensity = 8.5E12p
LE~32 eVs at injection
LE ~64 eVs after compression

Conclusions:
• Final LE growth depends on the rate of bunch compression.
• Seen about a factor of two LE growth during our studies.

Fast Bunch Compression and Stretching using Barrier RF System

Chandra Bhat*,
Bill Foster*,
Brian Chase,
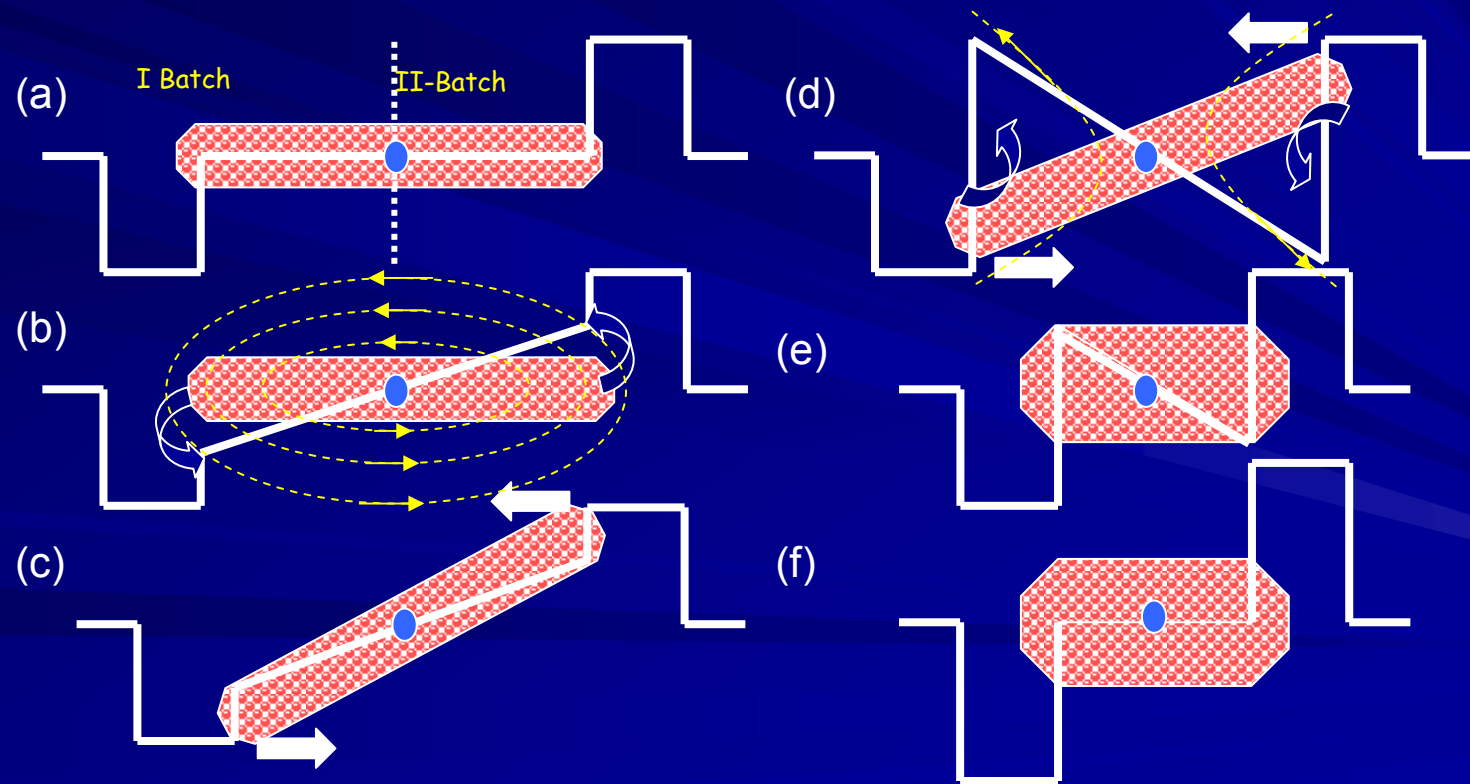Jim MacLachlan*,
Kiyomi Seiya,
Phillip Varghese,
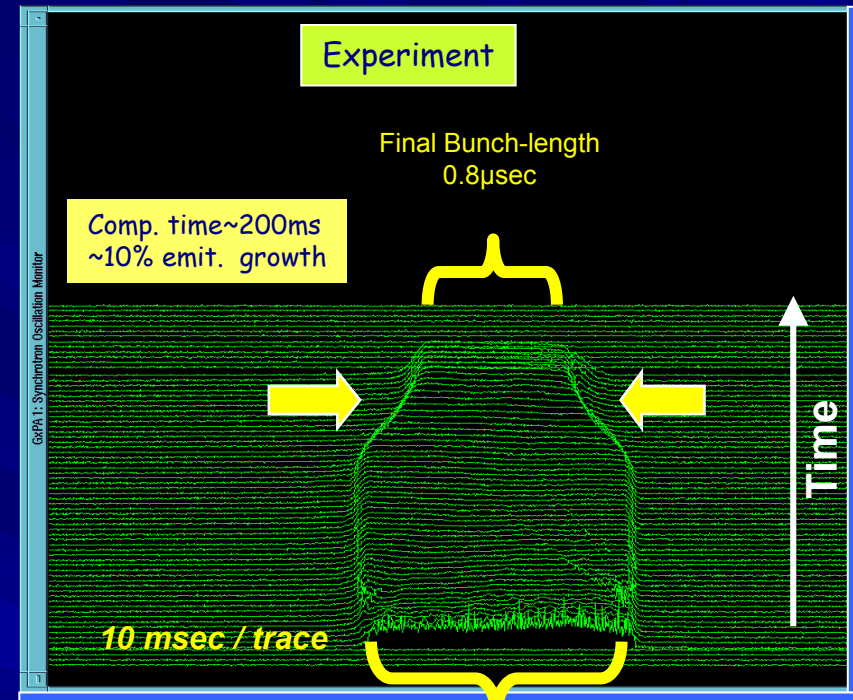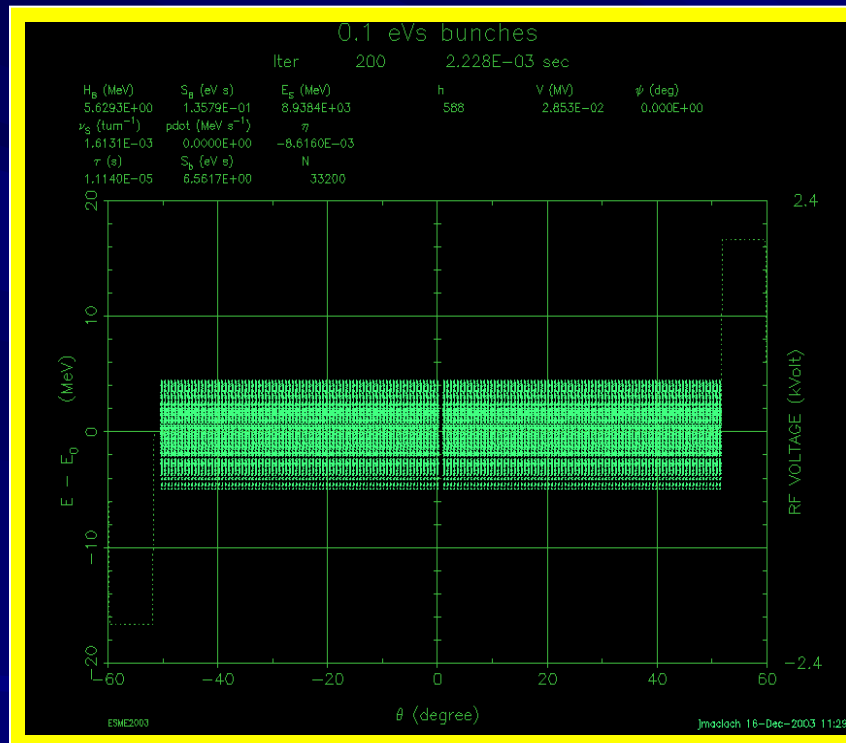Dave Wildman

Physics of Fast Bunch Compression:
Rotation of a bunch about rf stable and unstable point within a Barrier bucket

Fast Bunch Compression:
Symmetric Compression

Simulations: J. MacLachlan

Experiment

Final Bunch-length
0.8μsec

Comp. time~200ms
~10% emit. growth

Time

10 msec / trace

Injected Batch from Main Injector, Bunch Length=1.59 μsec

Parameters:
Barrier Pulse = ±2kV, Ramp Voltage = ± 1kV
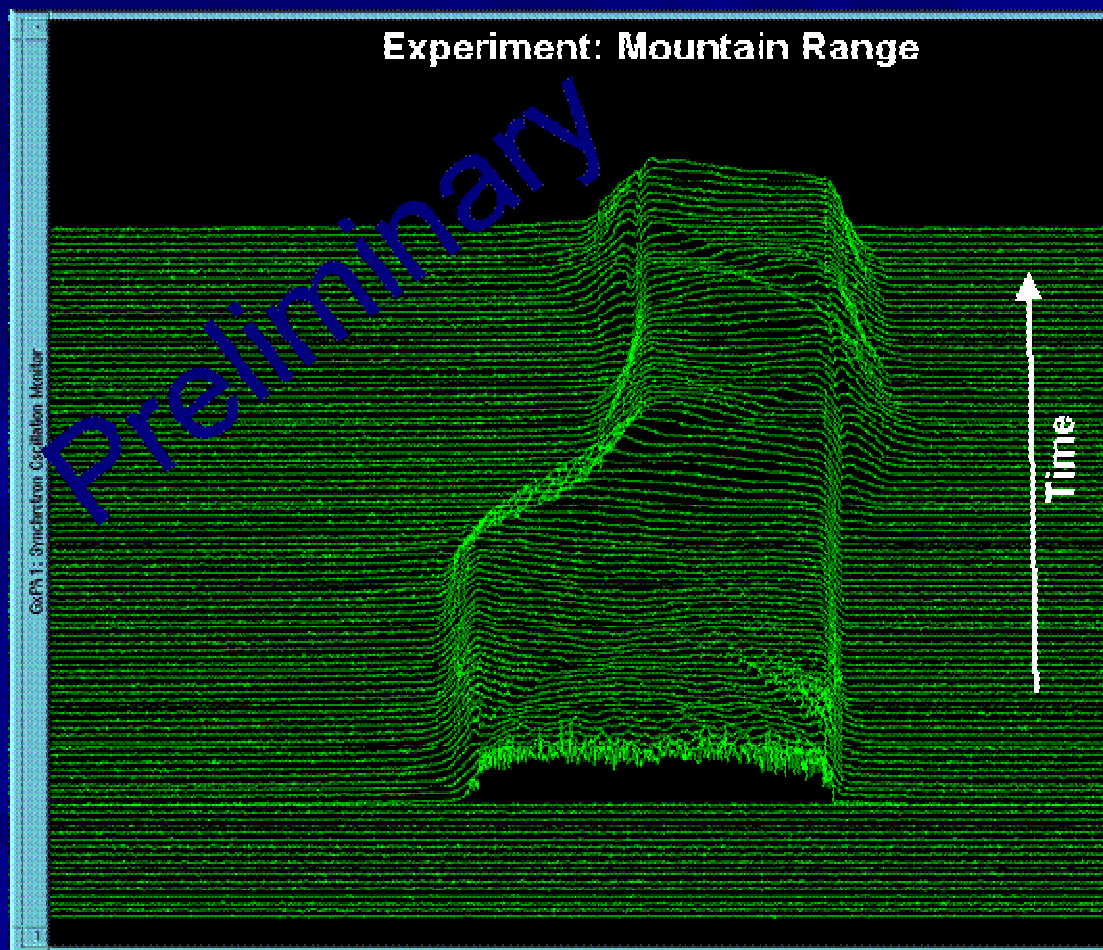Beam Intensity ~1.5E12p
LE (initial) ~16 eVs, LE (final)= LE= 18 eVs

Fast Bunch Compression:

Non--symmetric Compression
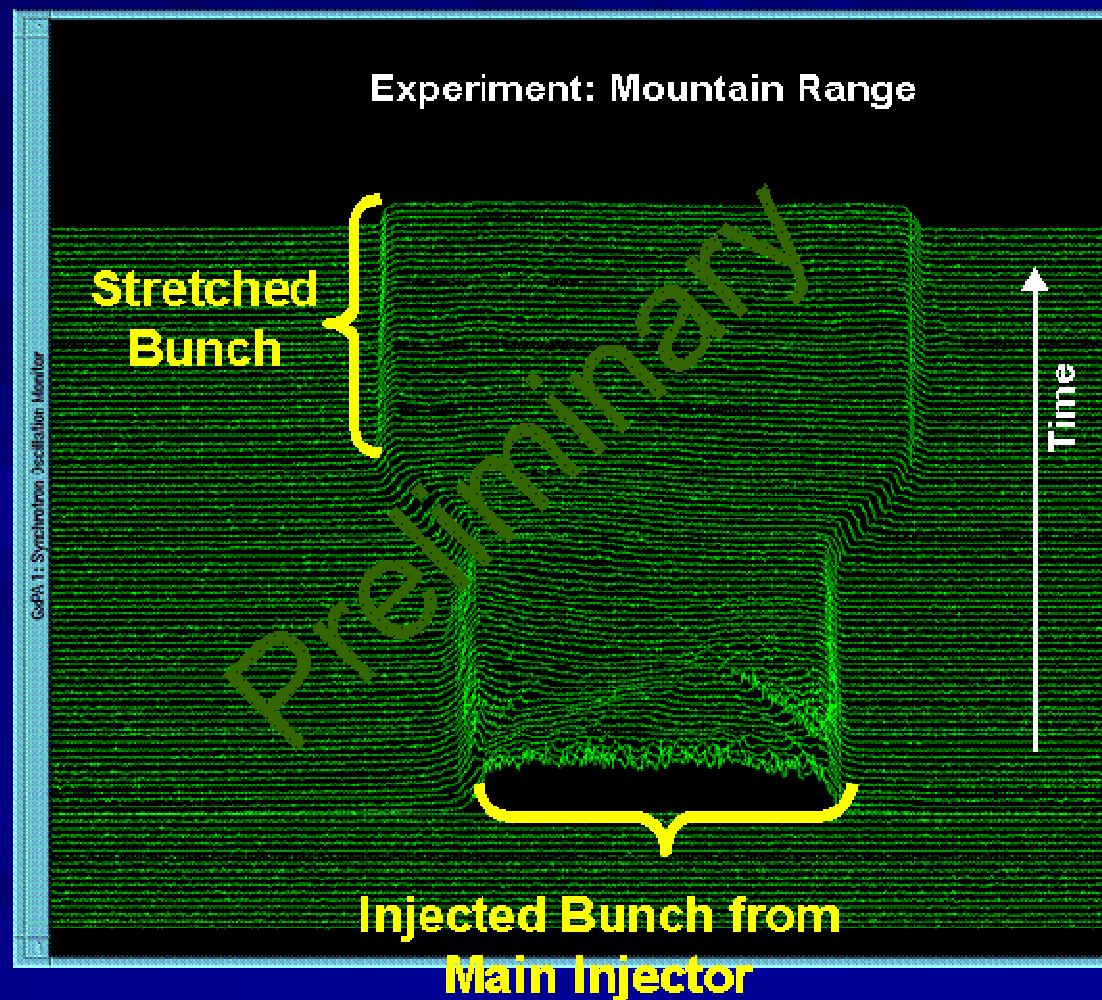
Experimental Demonstration

Schematic View

2nd Rotation

(b)

1st Rotation

(b)

Injection

(a)

Experiment: Mountain Range

Preliminary

Time
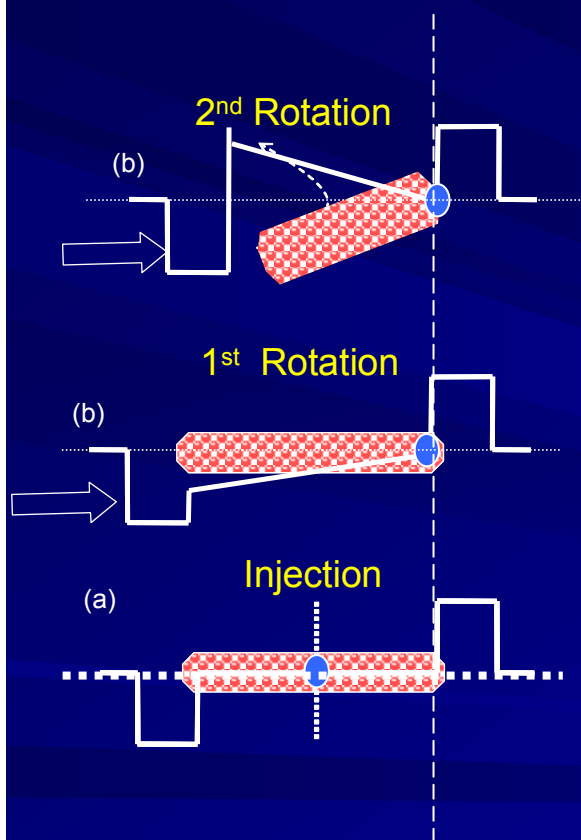
Bunch Stretching

Schematic View

(c) Rotation about stable pt.

(b) Rotation about unstable pt.

(a) Injection

Experiment: Mountain Range

Stretched Bunch

Time

Injected Bunch from Main Injector
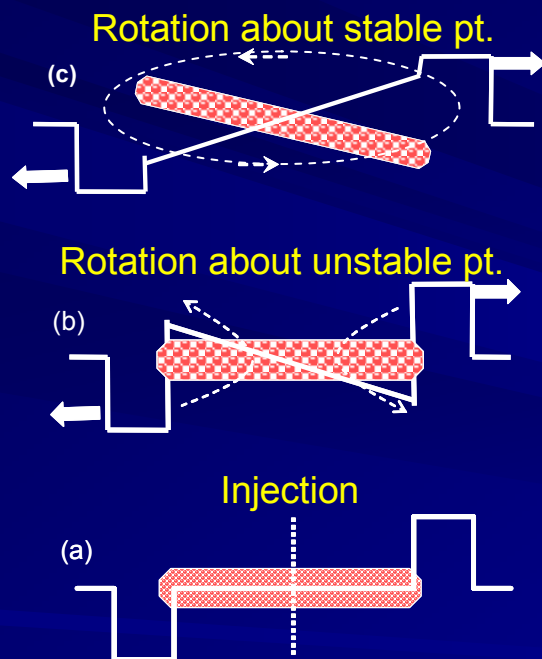
Fast Bunch Cogging

Schematic View

Injection

(a)

(b)

Experiment: Mountain Range

Cogged Bunch

Time

Preliminary

Injected Bunch from Main Injector

GxPA I: Synchrotron Oscillation Monitor