Electron Storage Ring As a Single Shot Linac Beam Monitor

Y. Shoji
K. Takeda

S. Suzuki
T. Asaka
Y. Minagawa
Y. Takemura

NewSUBARU, LASTI, University of Hyogo

SPring-8, JASRI

Electron Storage Ring As a Single Shot Linac Beam Monitor

Y. Shoji
K. Takeda

S. Suzuki
T. Asaka
Y. Minagawa
Y. Takemura

NewSUBARU, LASTI, University of Hyogo

SPring-8, JASRI

Electron Storage Ring As a Single Shot Linac Beam Monitor

Y. Shoji
K. Takeda

S. Suzuki
T. Asaka
Y. Minagawa
Y. Takemura

NewSUBARU, LASTI, University of Hyogo

SPring-8, JASRI

Electron Storage Ring As a Single Shot Linac Beam Monitor

Y. Shoji
K. Takeda

S. Suzuki
T. Asaka
Y. Minagawa
Y. Takemura

NewSUBARU, LASTI, University of Hyogo

SPring-8, JASRI

SPring-8 Linac & NewSUBARU

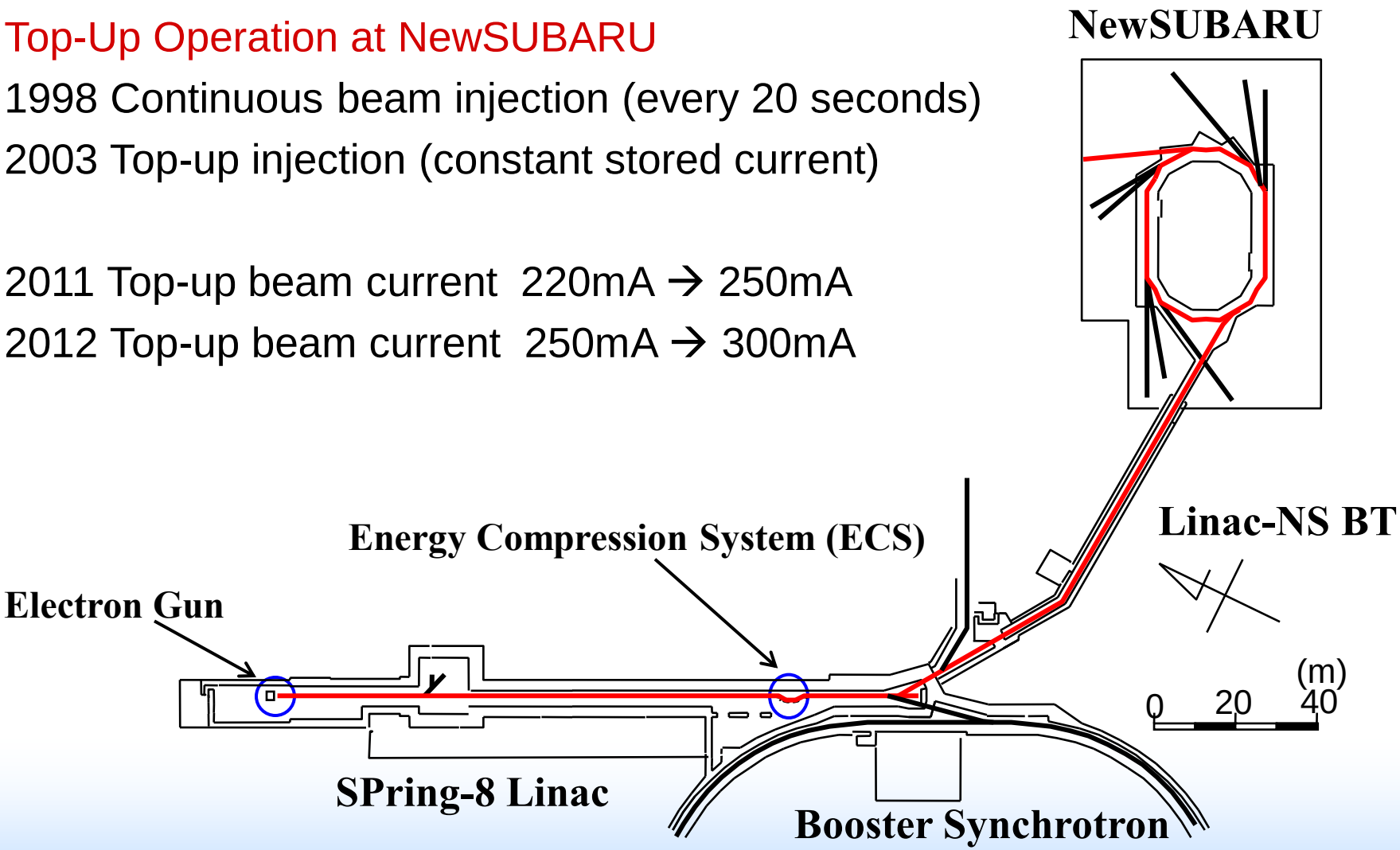
Top-Up Operation at NewSUBARU

1998 Continuous beam injection (every 20 seconds)

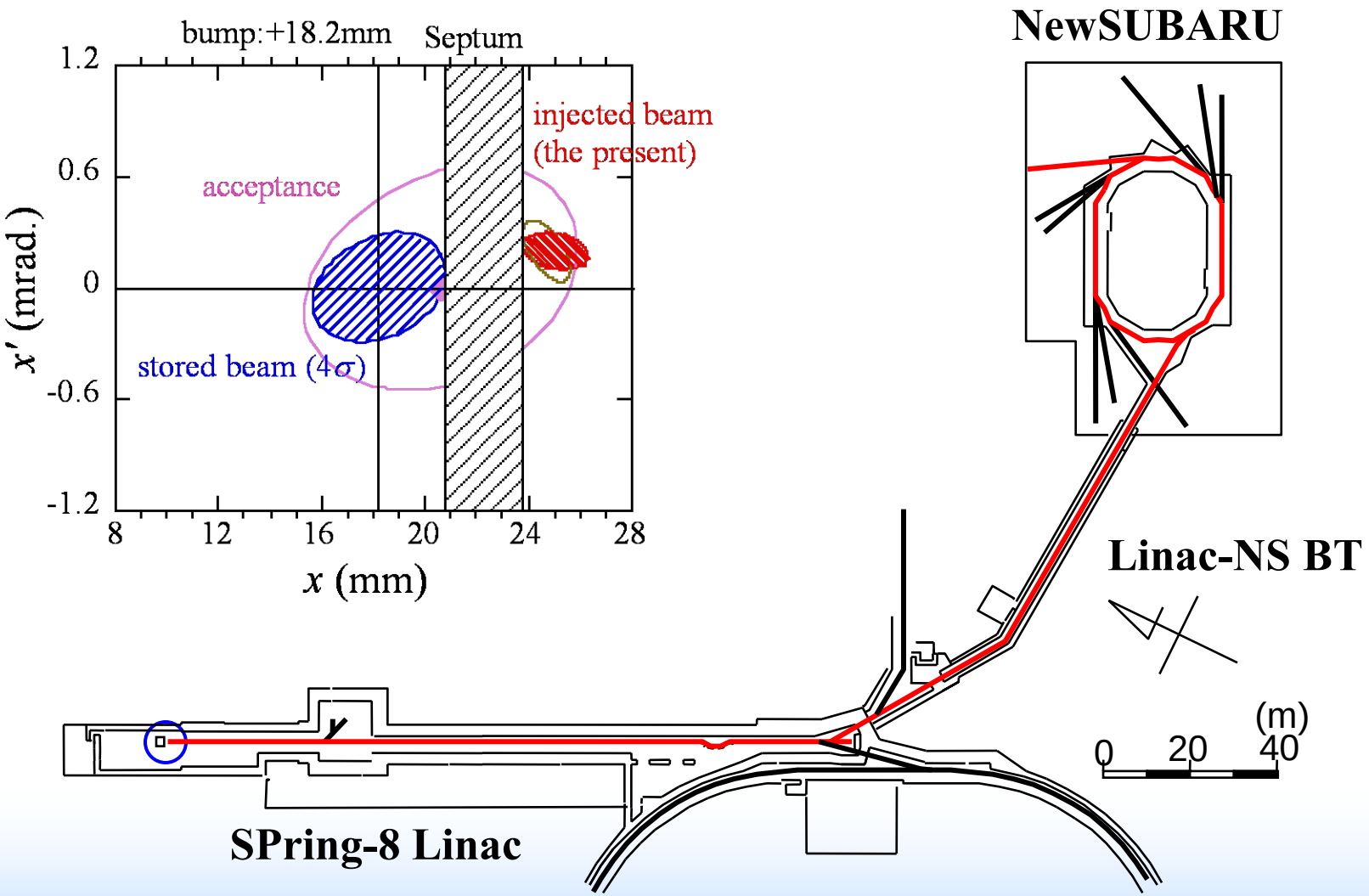
2003 Top-up injection (constant stored current)

2011 Top-up beam current 220mA → 250mA

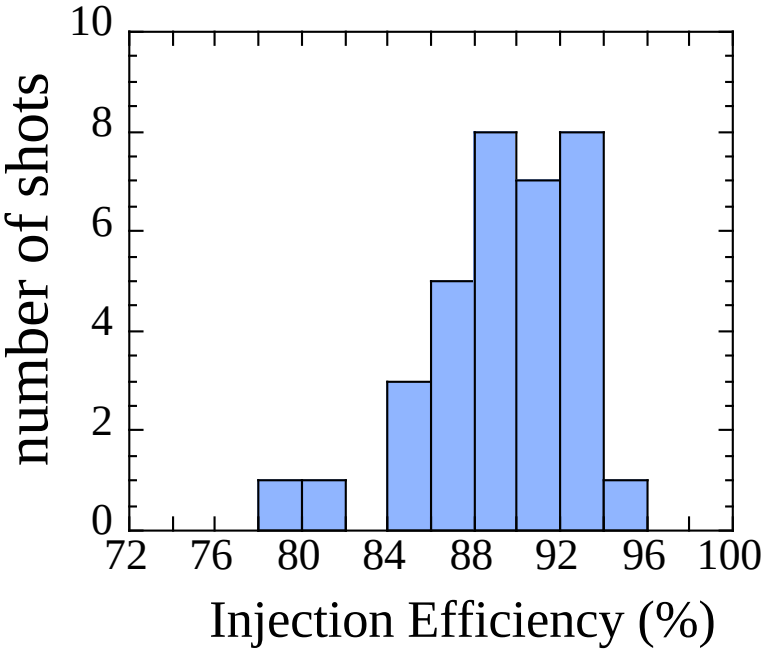
2012 Top-up beam current 250mA → 300mA



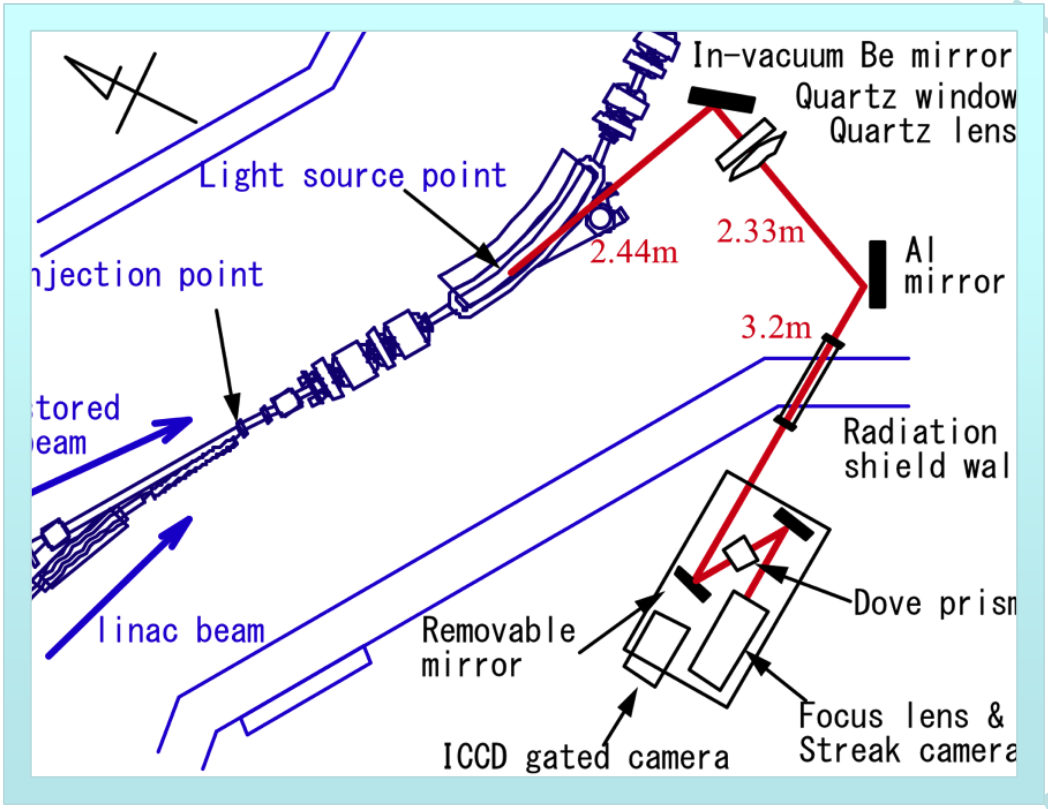
SPring-8 Linac & NewSUBARU



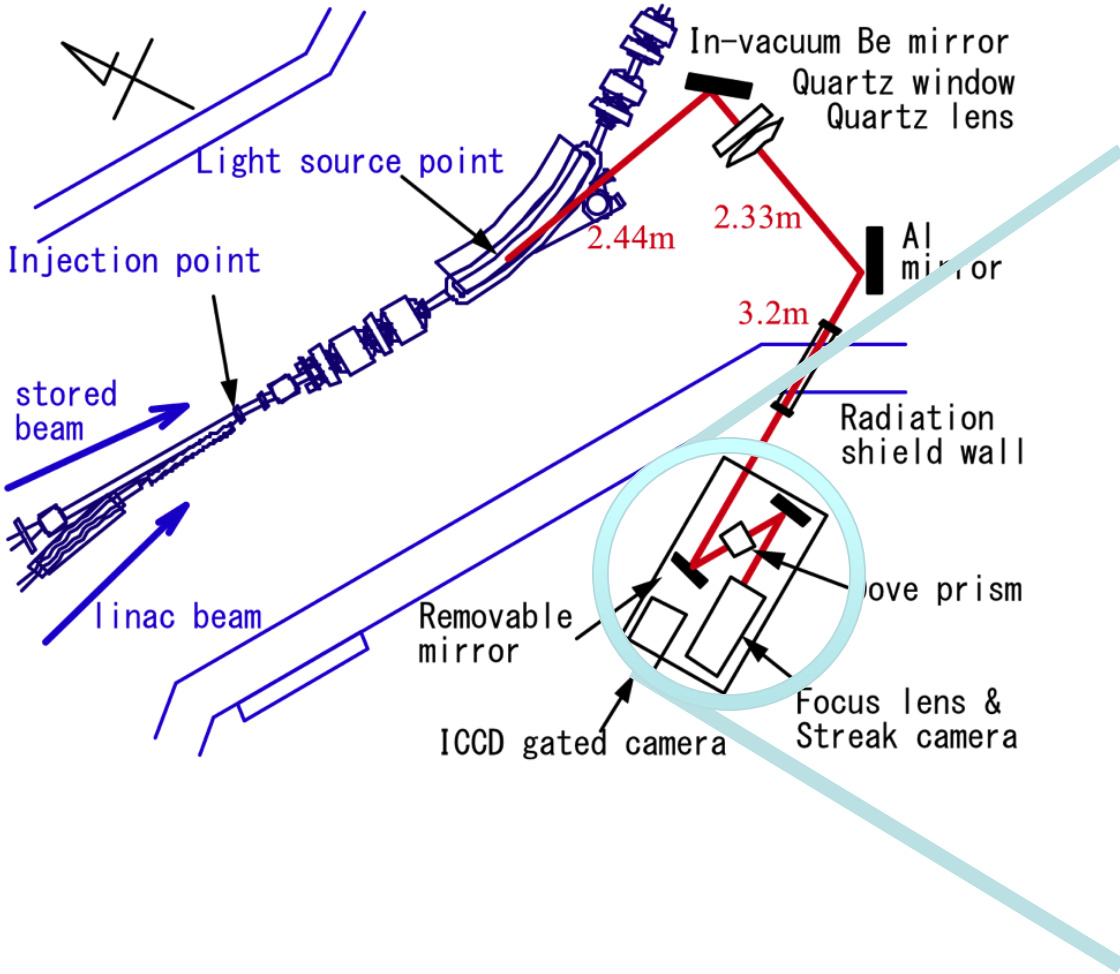
Fluctuation of Injection Efficiency

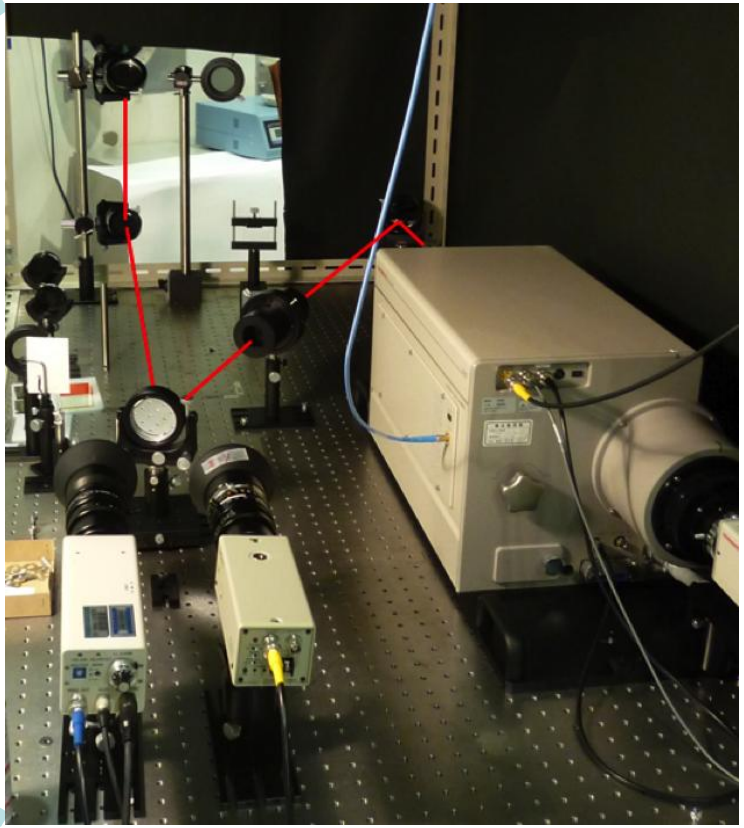


SR5 (Visible Light Monitor Line)

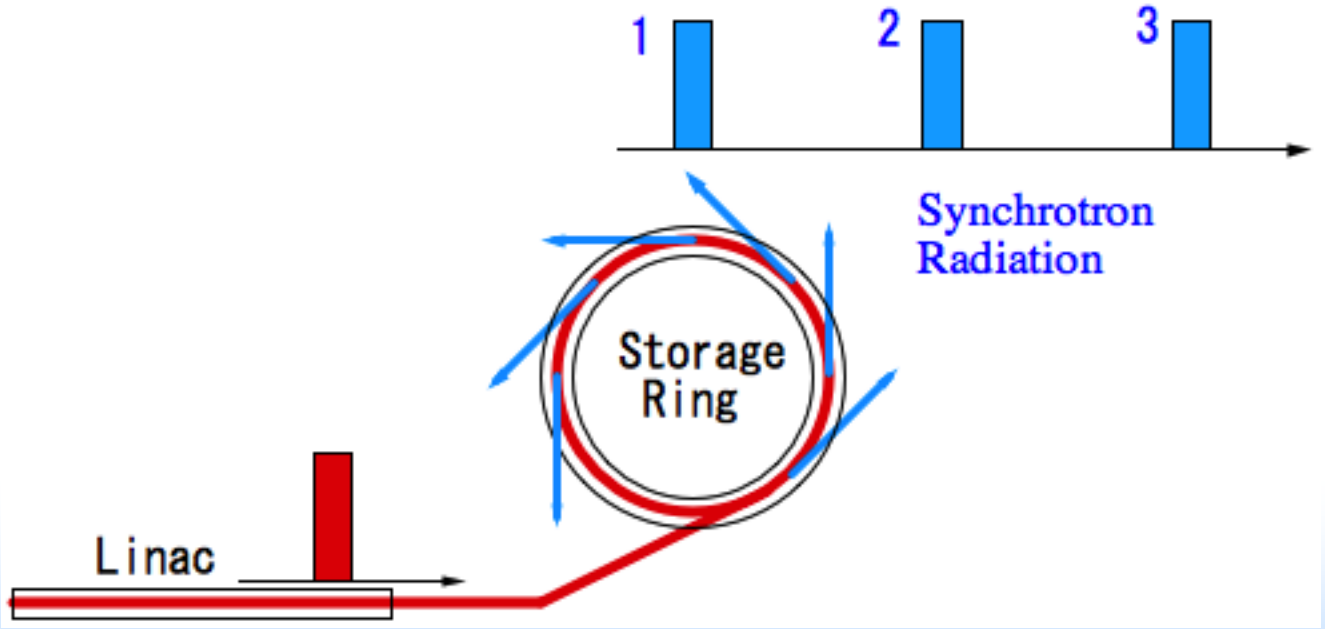


SR5 (Visible Light Monitor Line)

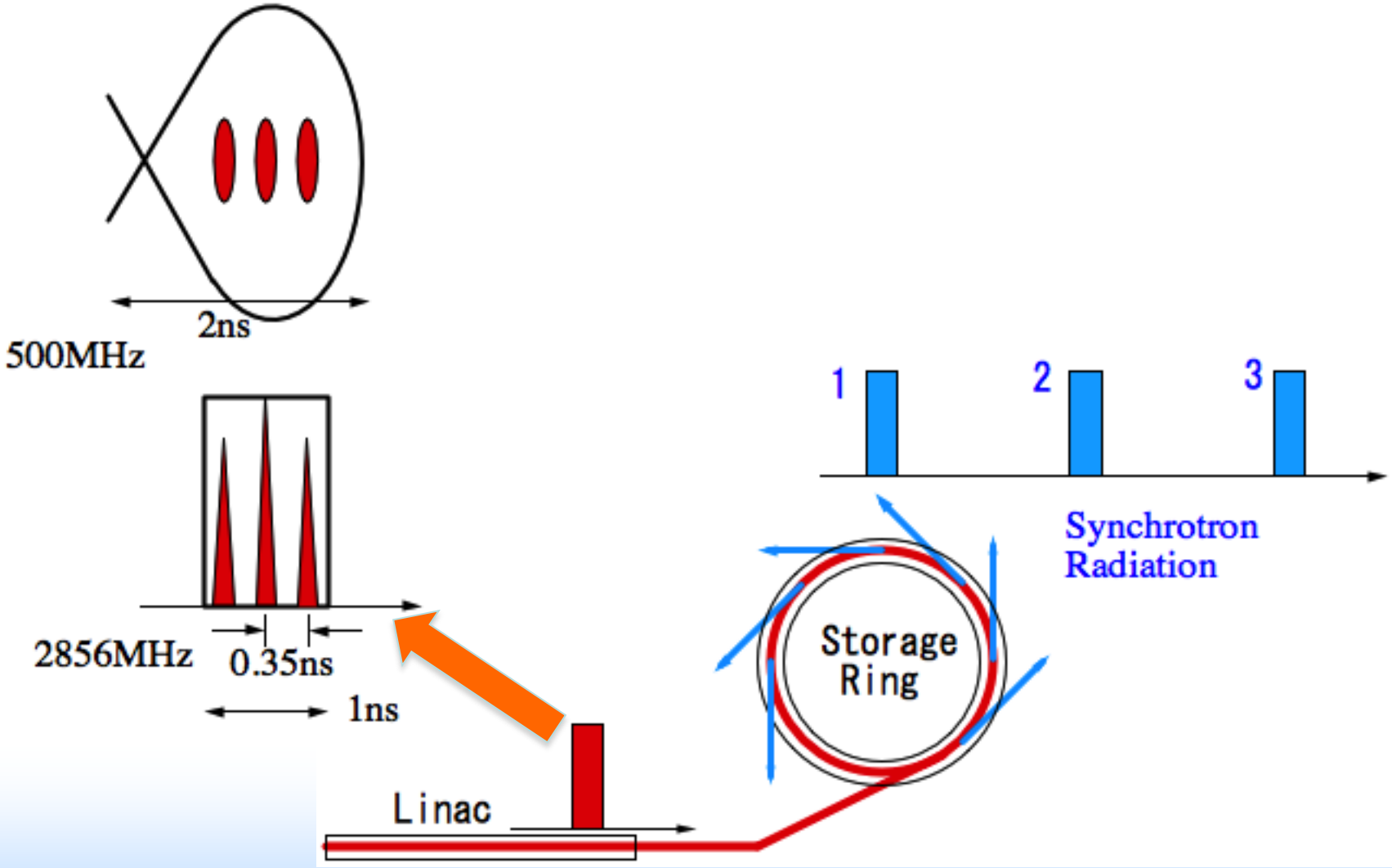




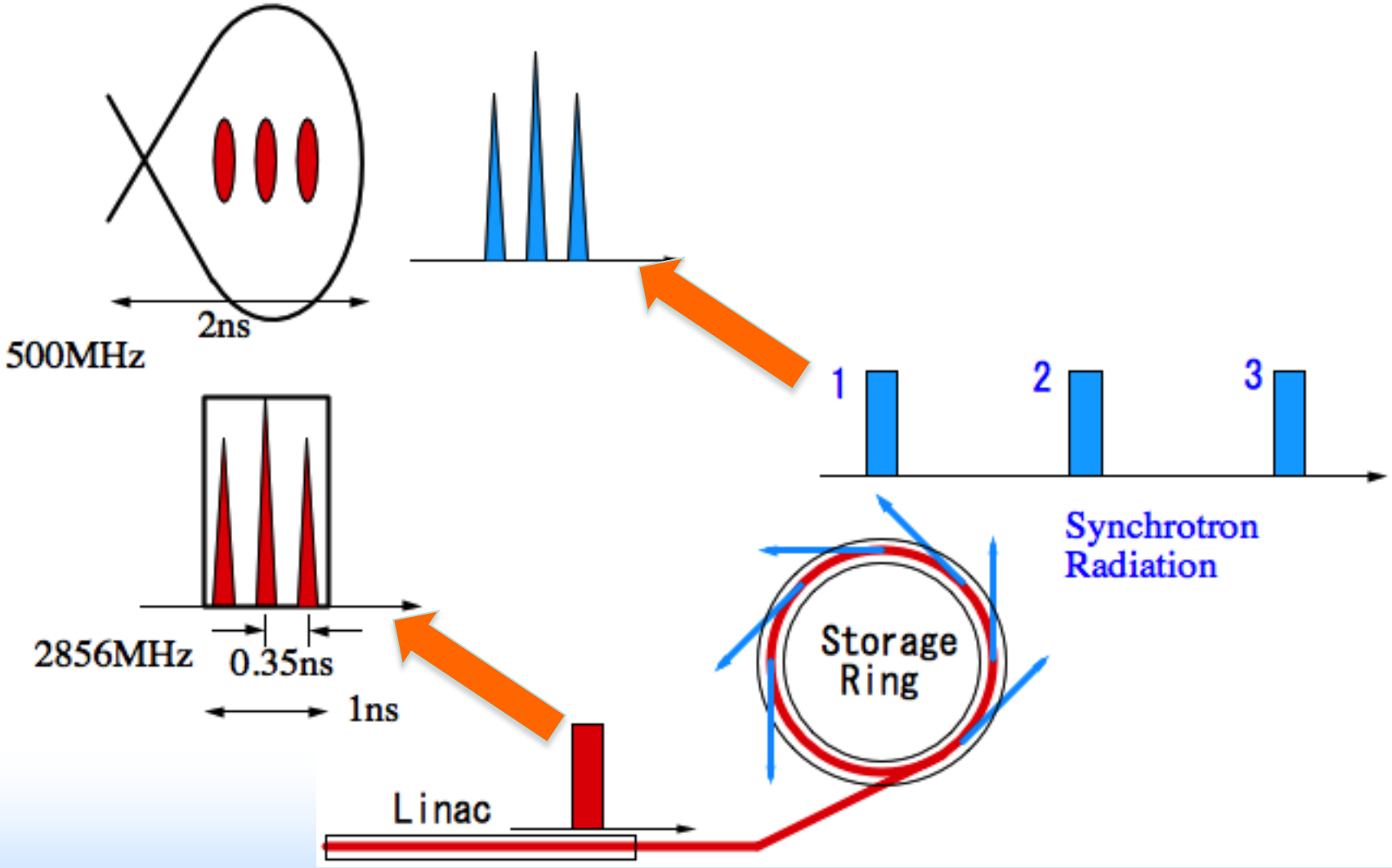
Electron Storage Ring
as a Single Shot Linac Beam Monitor



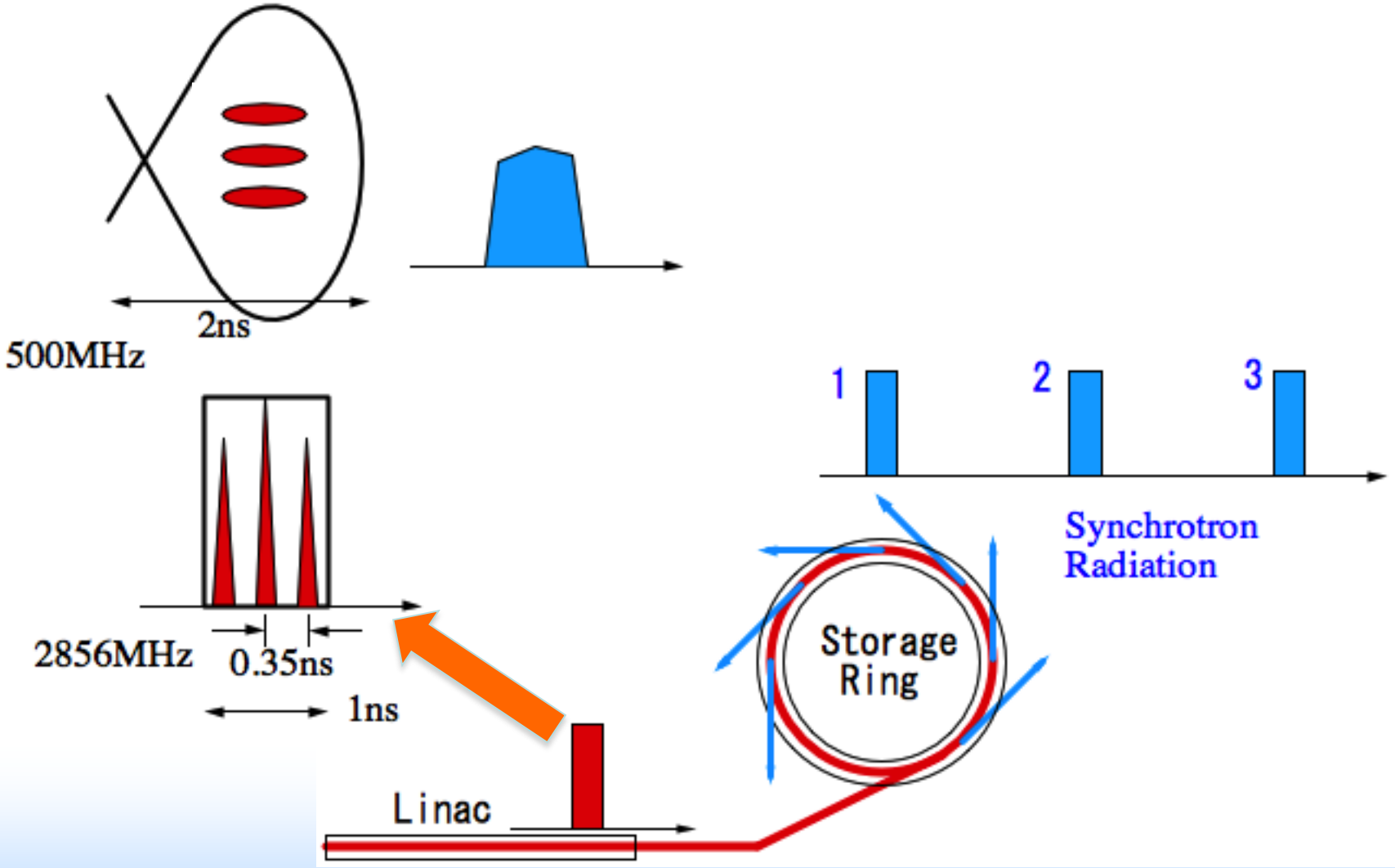
Electron Storage Ring
as a Single Shot Linac Beam Monitor



Electron Storage Ring
as a Single Shot Linac Beam Monitor



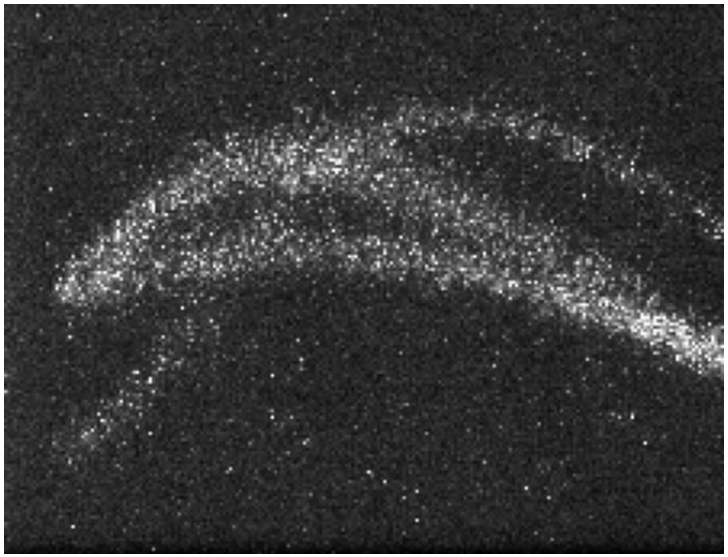
Electron Storage Ring
as a Single Shot Linac Beam Monitor



Bunch Structure and Energy Profile

Dual Sweep Streak Camera Image

123 μs =307 turns

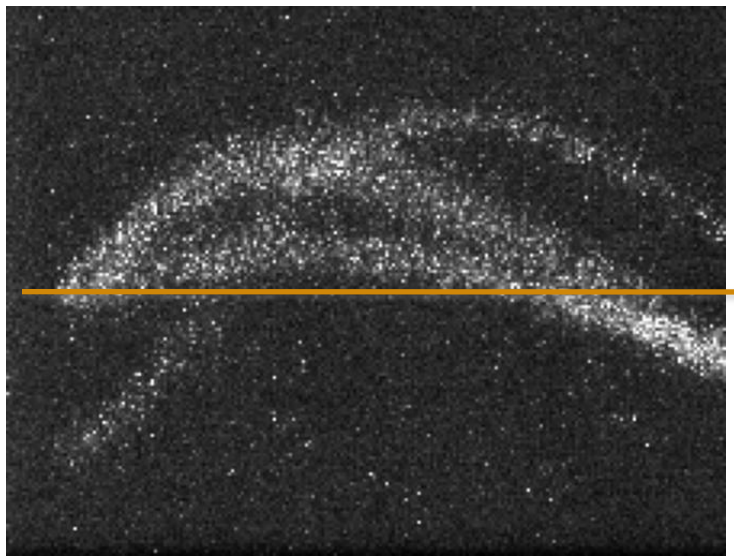


ring rf phase

1.27ns=230^{O}

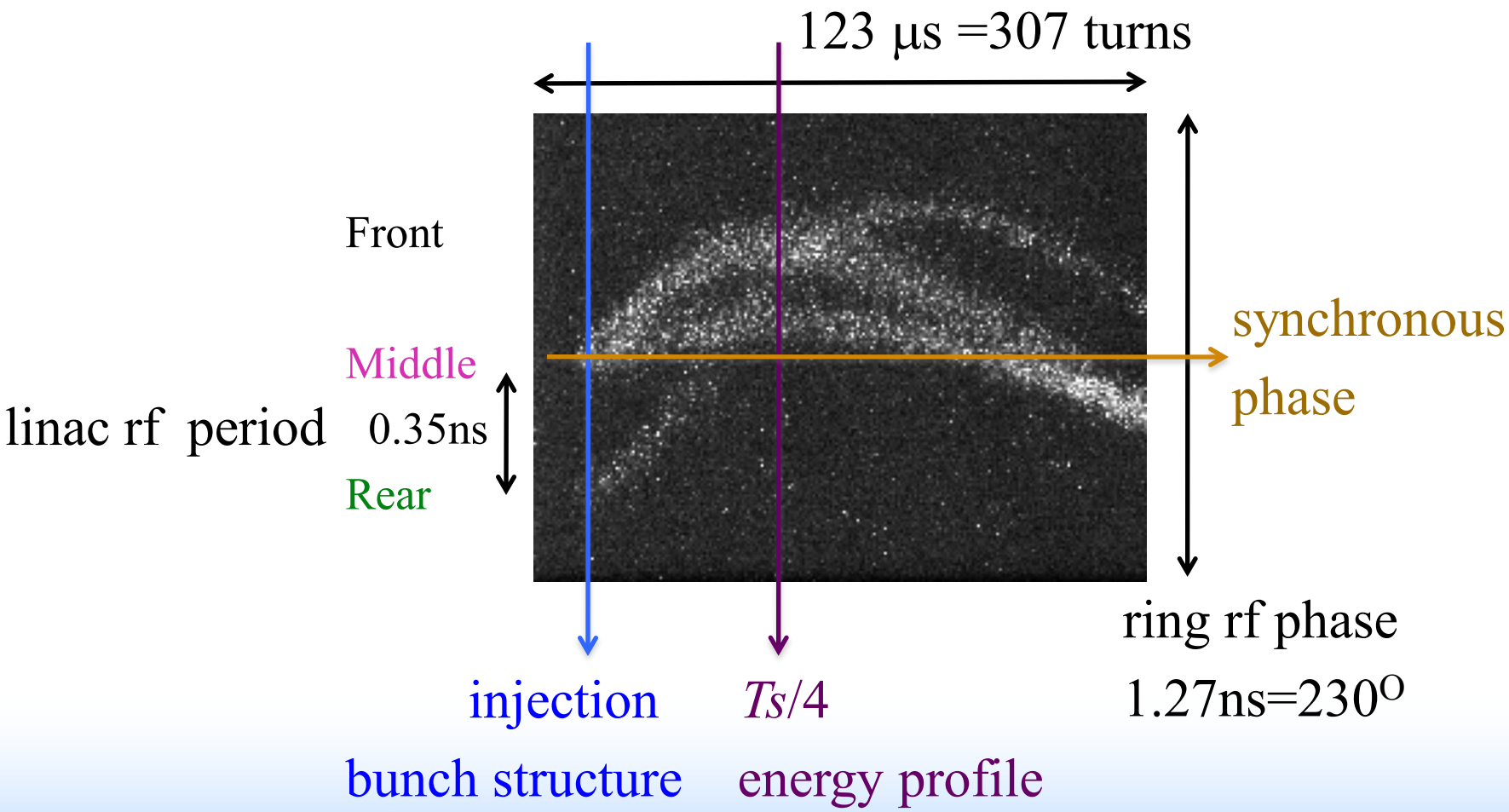
Bunch Structure and Energy Profile

Dual Sweep Streak Camera Image

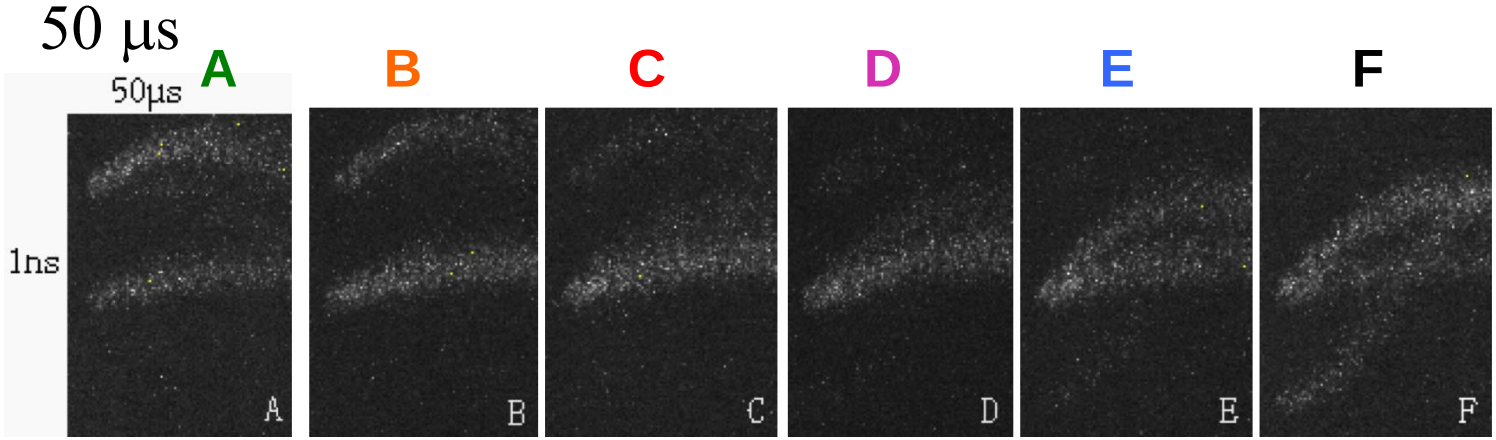


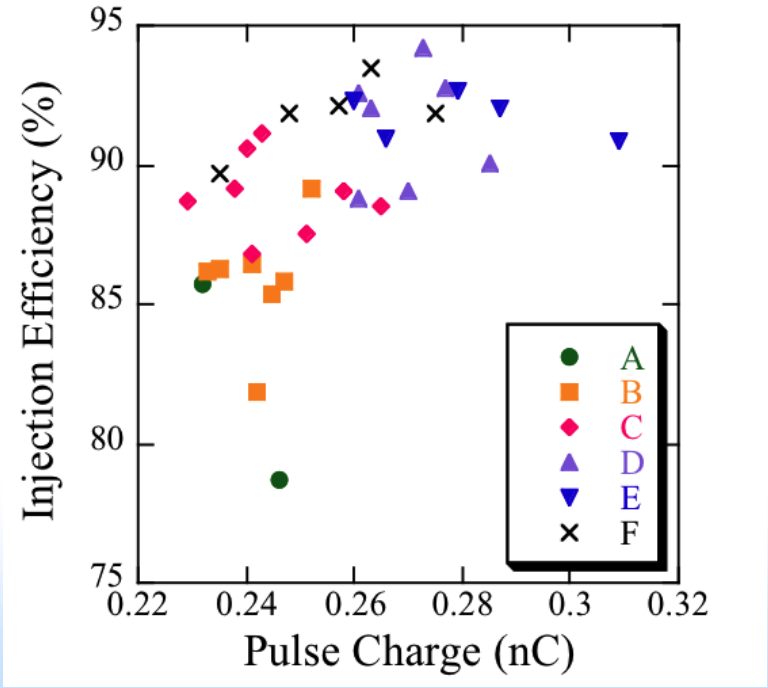
Bunch Structure and Energy Profile

Dual Sweep Streak Camera Image



Fluctuation of Longitudinal Beam Profiles



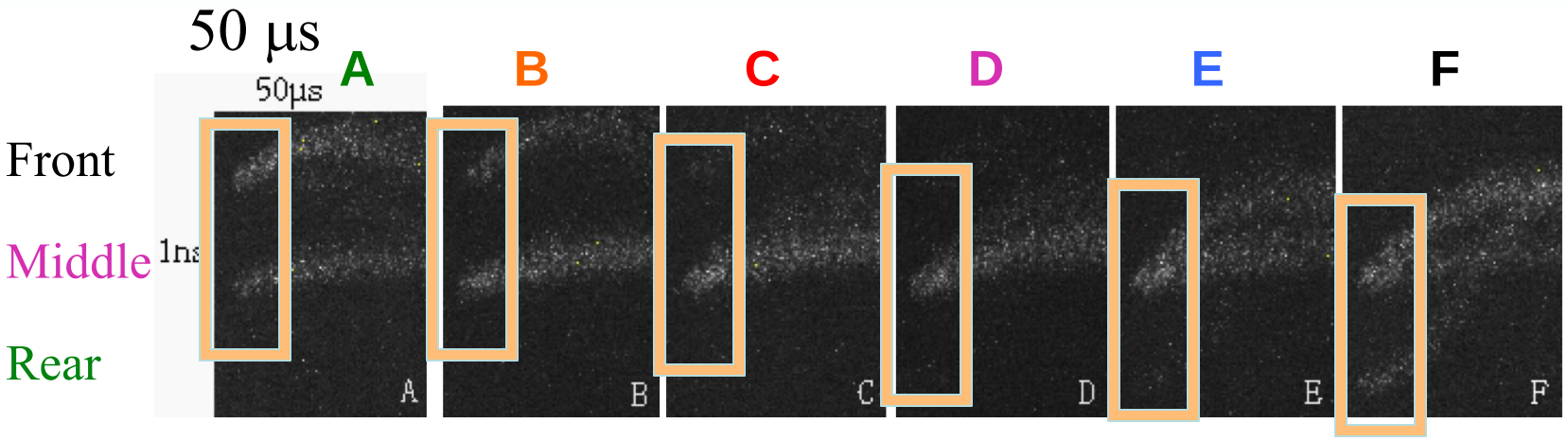


Shot-to-shot fluctuation of injection efficiency

A and **B** had worse efficiency

E and **F** had good efficiency

Fluctuation of Longitudinal Beam Profiles



Shot-to-shot fluctuation of bunch structure

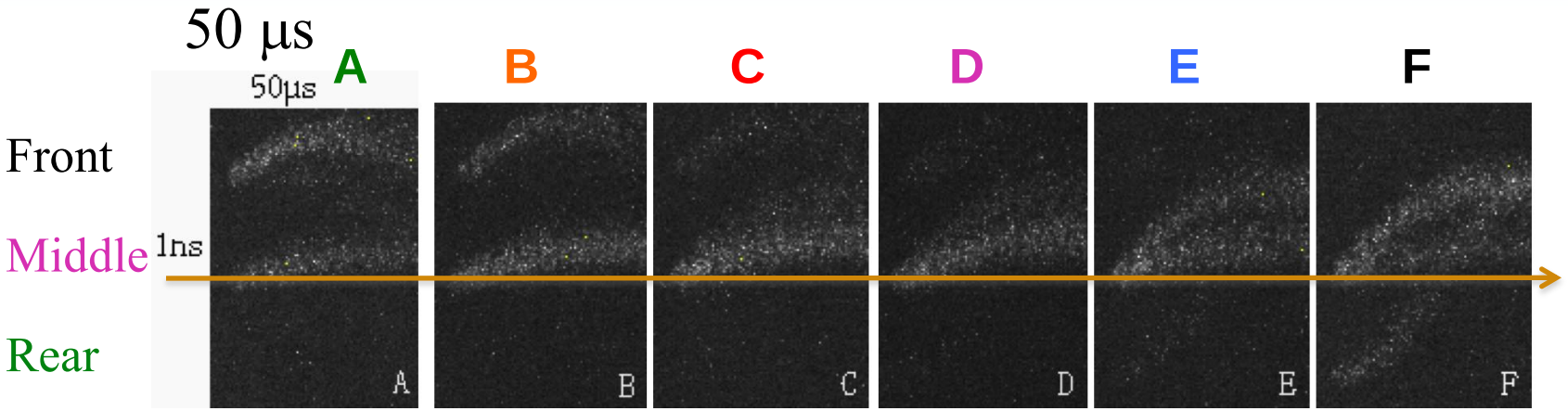
Linac rf phase was locked to the ring rf phase

Pulse had two 2 bunches → Pulse width = 0.7 ns

Pulse gate had a timing jitter 0.2 - 0.3ns ?

(Grid voltage pulse of thermionic electron gun)

Fluctuation of Longitudinal Beam Profiles



Shot-to-shot fluctuation of bunch structure

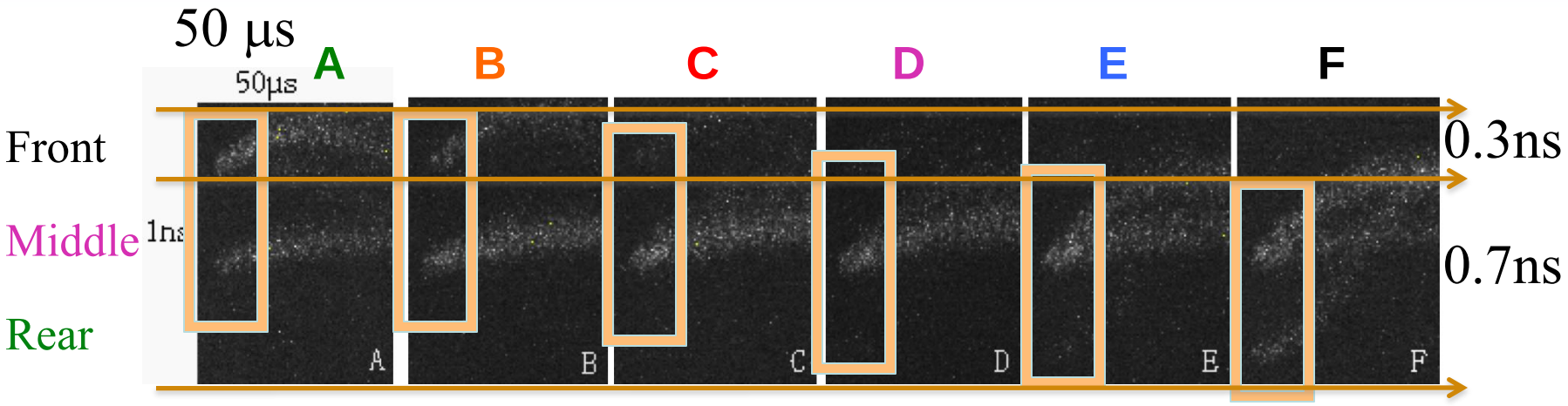
Linac rf phase was locked to the ring rf phase

Pulse had two 2 bunches → Pulse width = 0.7 ns

Pulse gate had a timing jitter 0.2 - 0.3ns ?

(Grid voltage pulse of thermionic electron gun)

Fluctuation of Longitudinal Beam Profiles



Shot-to-shot fluctuation of bunch structure

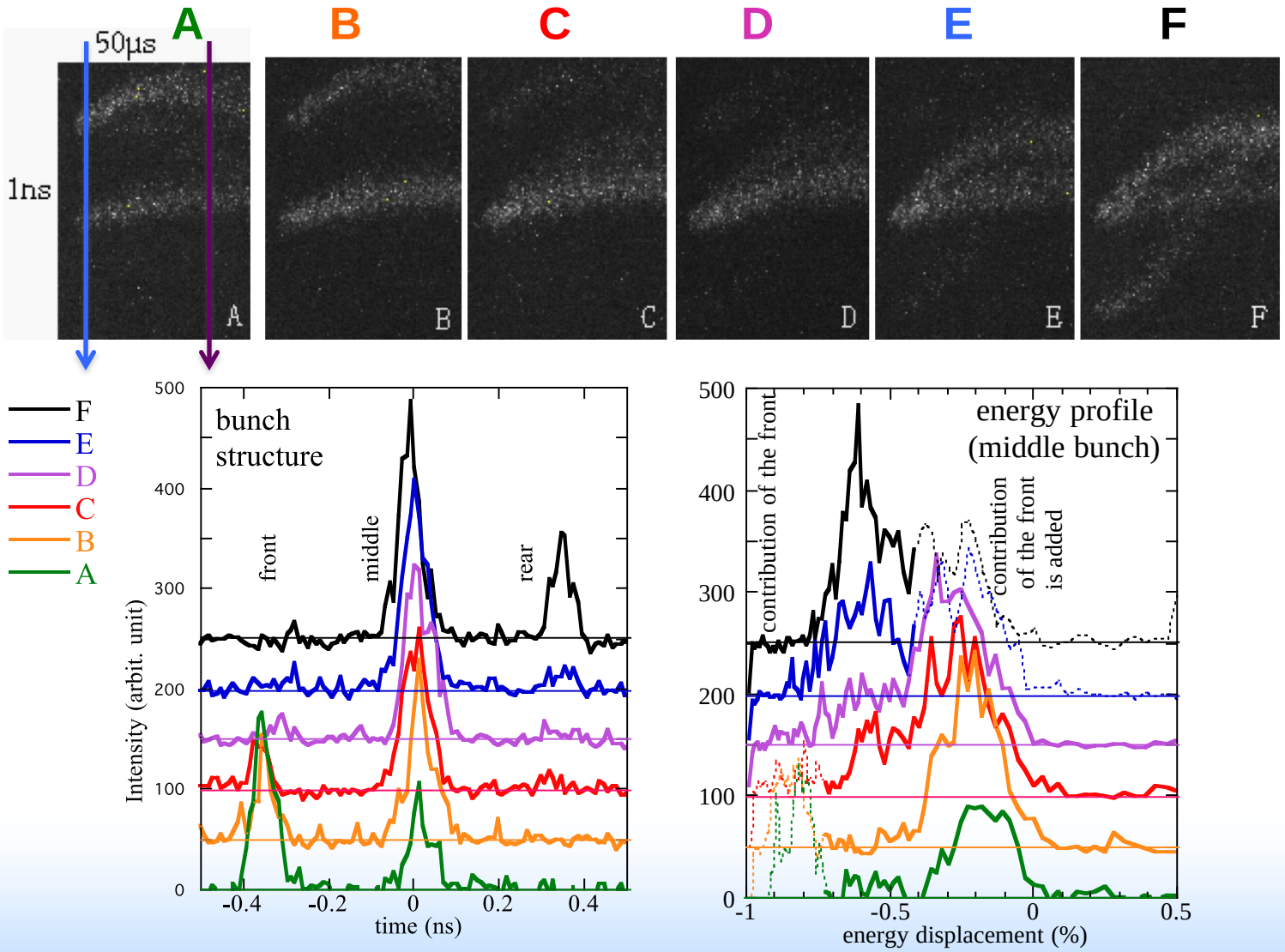
Linac rf phase was locked to the ring rf phase

Pulse had two 2 bunches → Pulse width = 0.7 ns

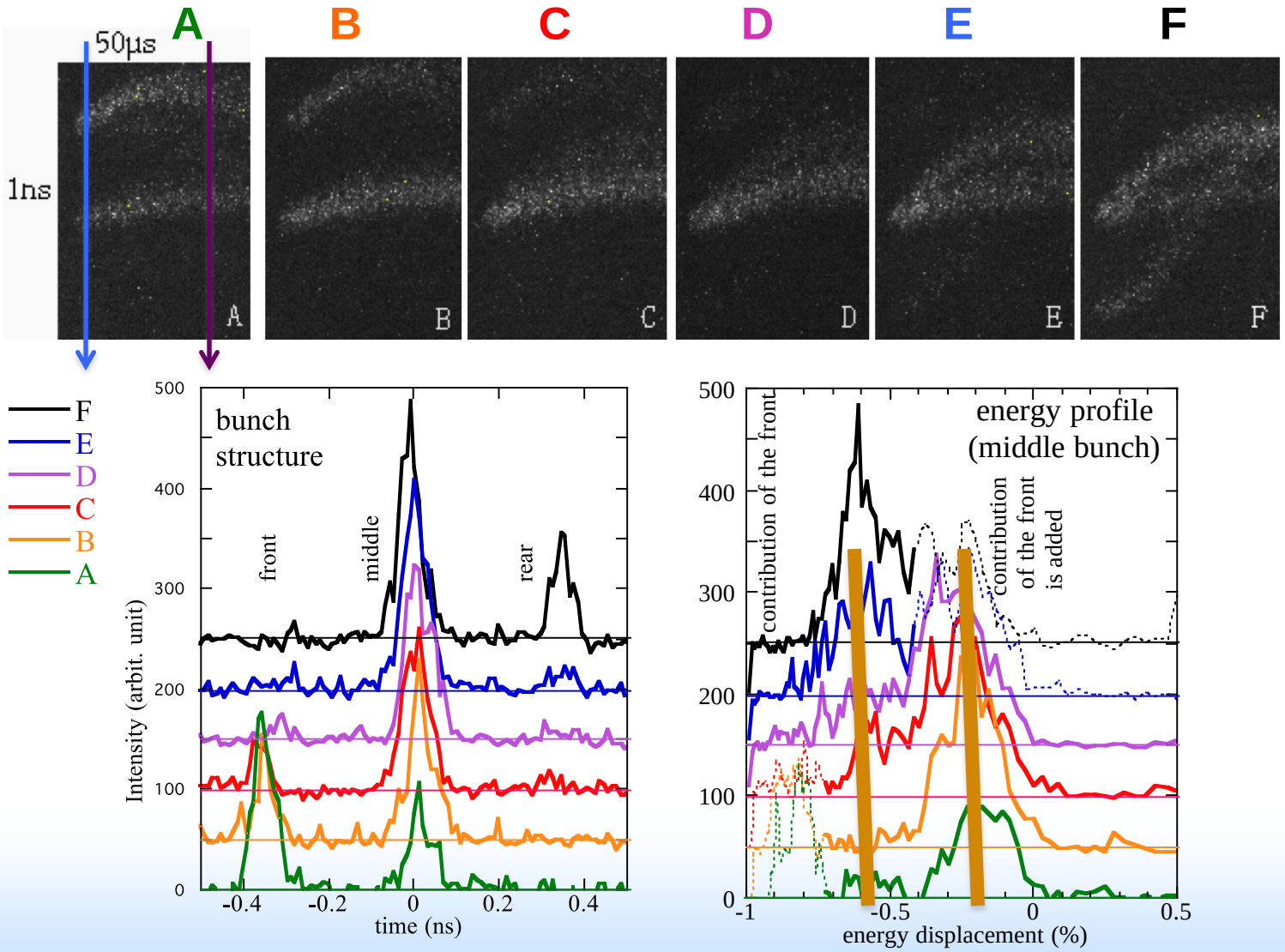
Pulse gate had a timing jitter 0.2 - 0.3ns ?

(Grid voltage pulse of thermionic electron gun)

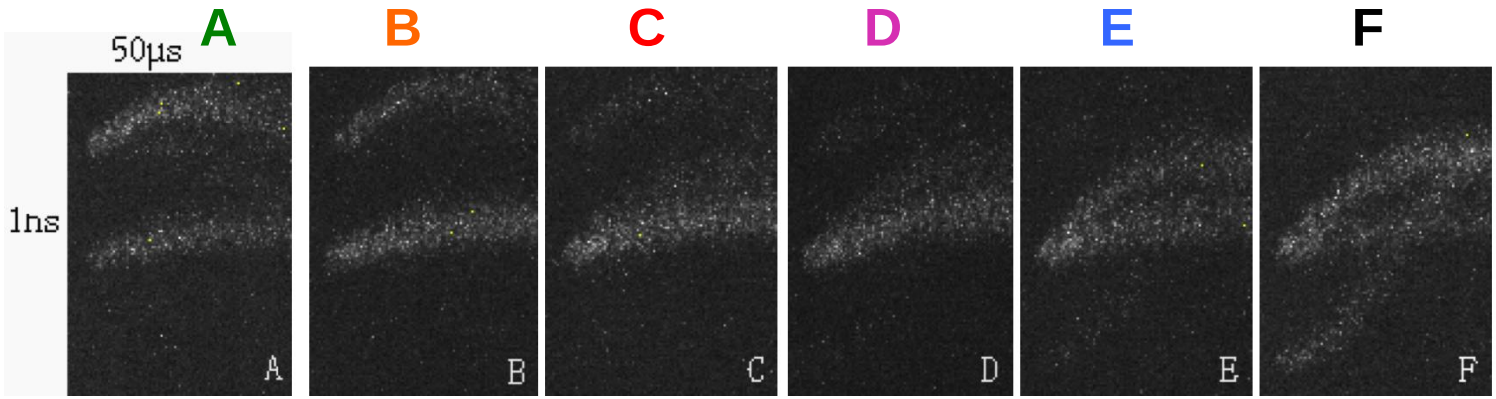
Fluctuation of Longitudinal Beam Profiles

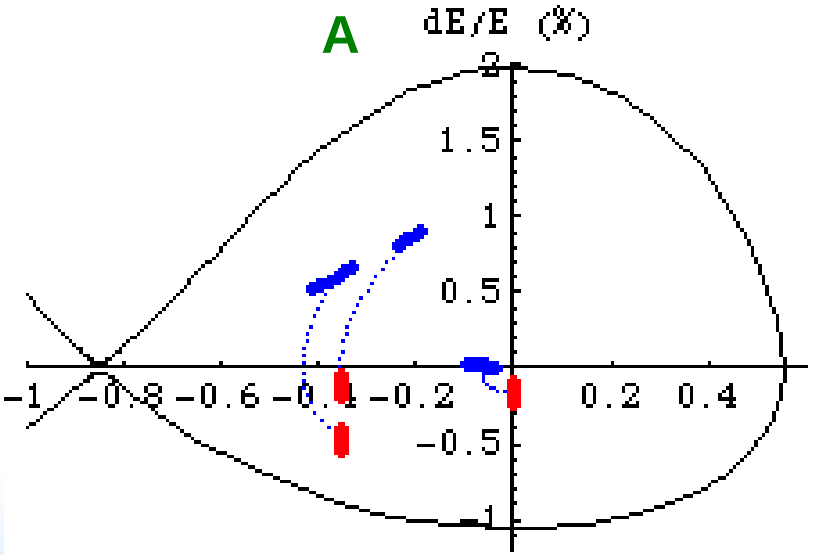


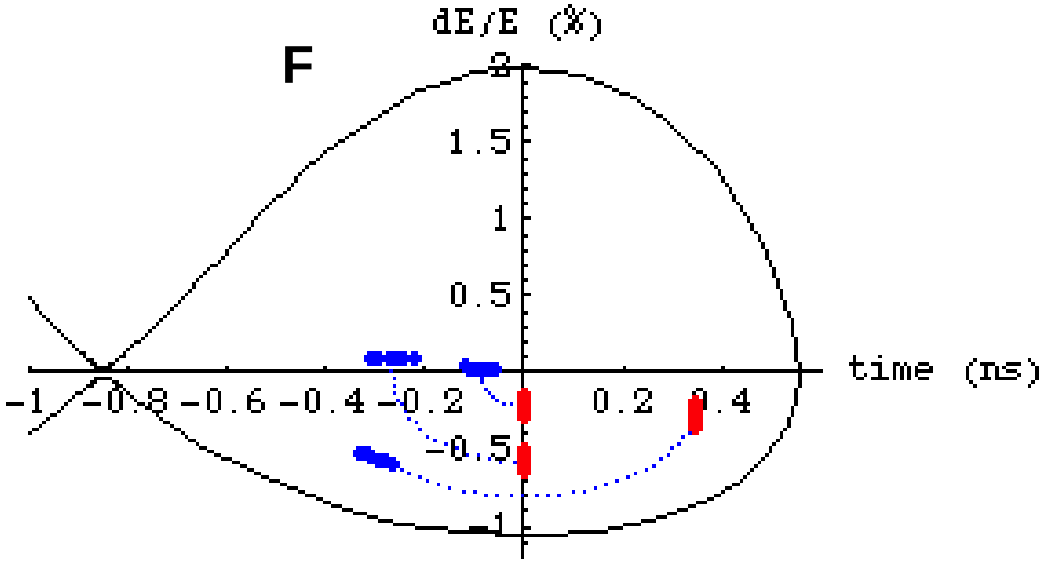
Fluctuation of Longitudinal Beam Profiles



Fluctuation of Longitudinal Beam Profiles

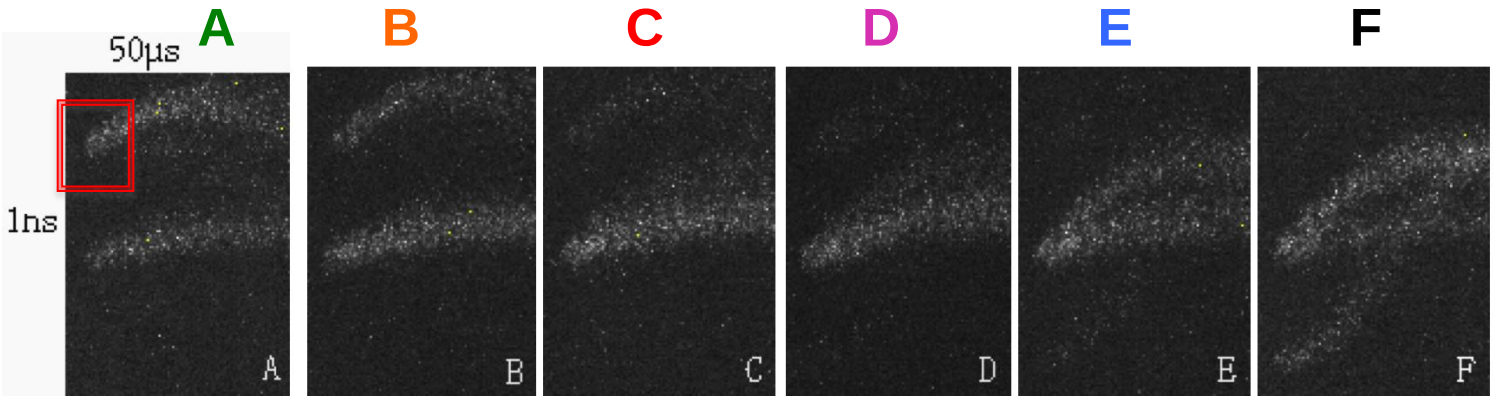


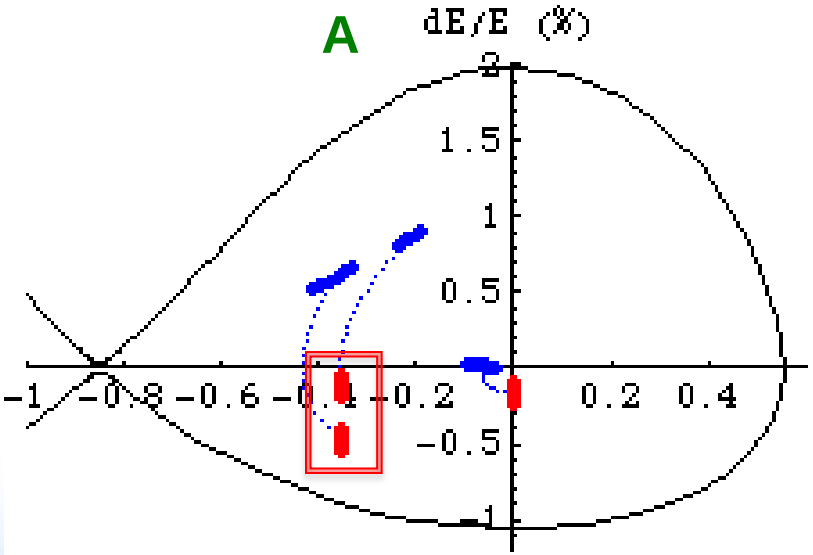


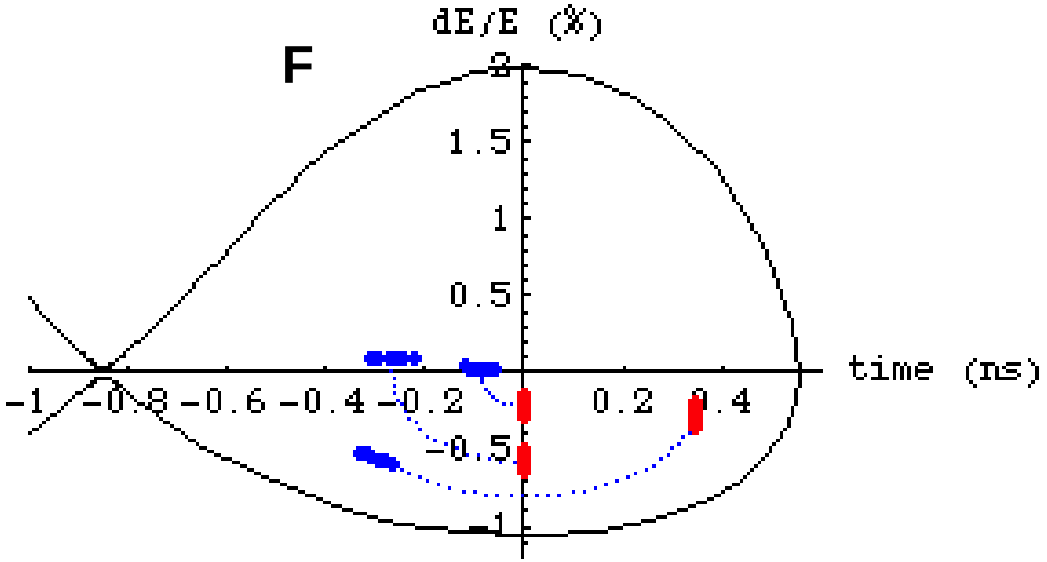


Fluctuation of Longitudinal Beam Profiles

front

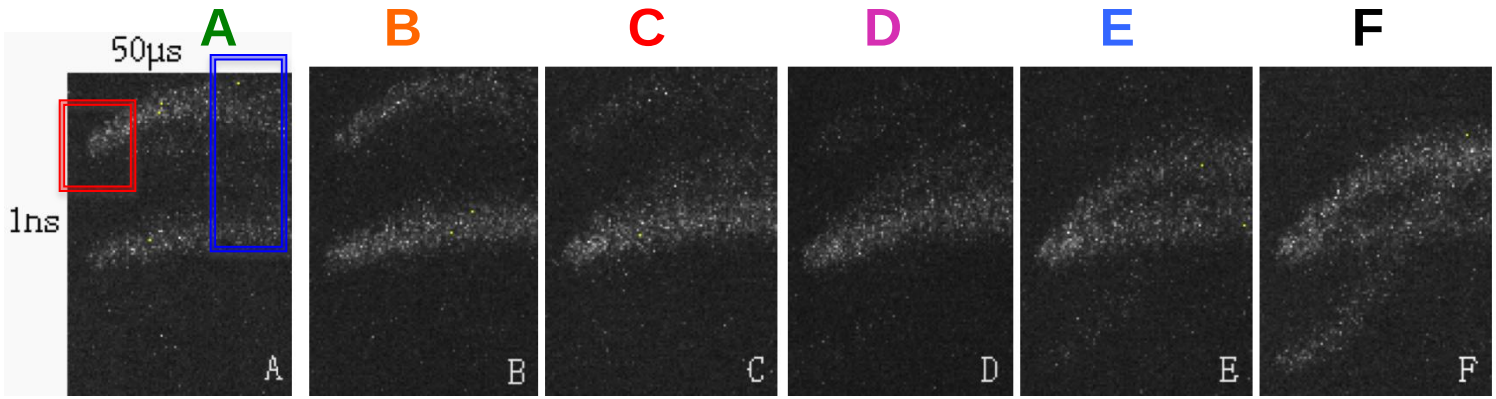


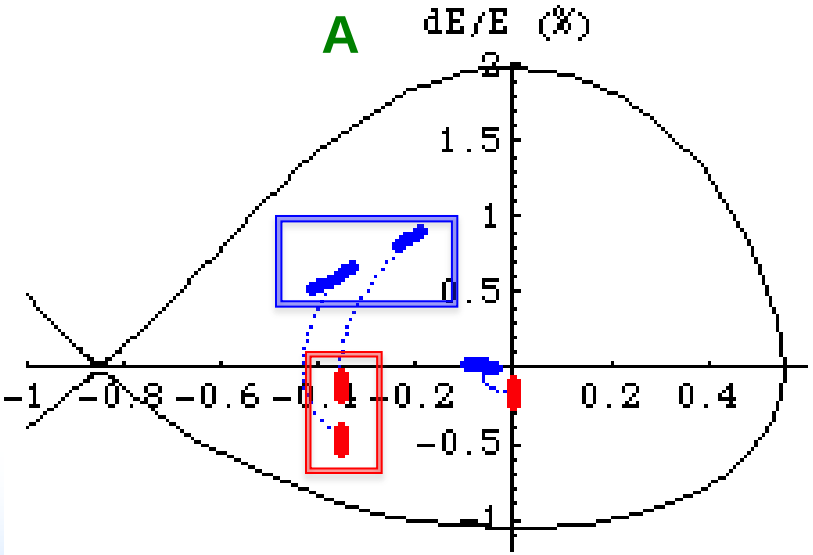


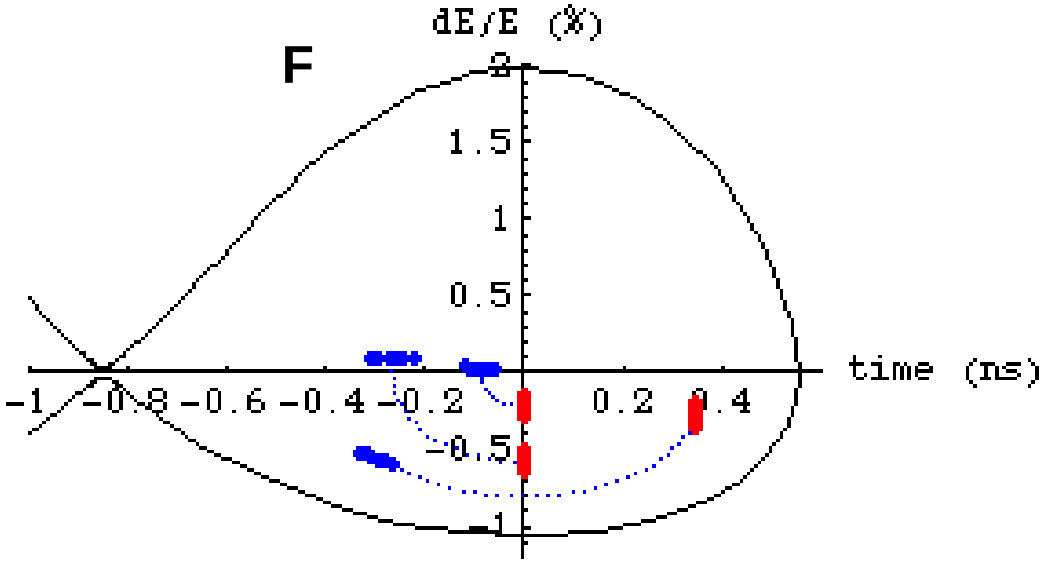


Fluctuation of Longitudinal Beam Profiles

front



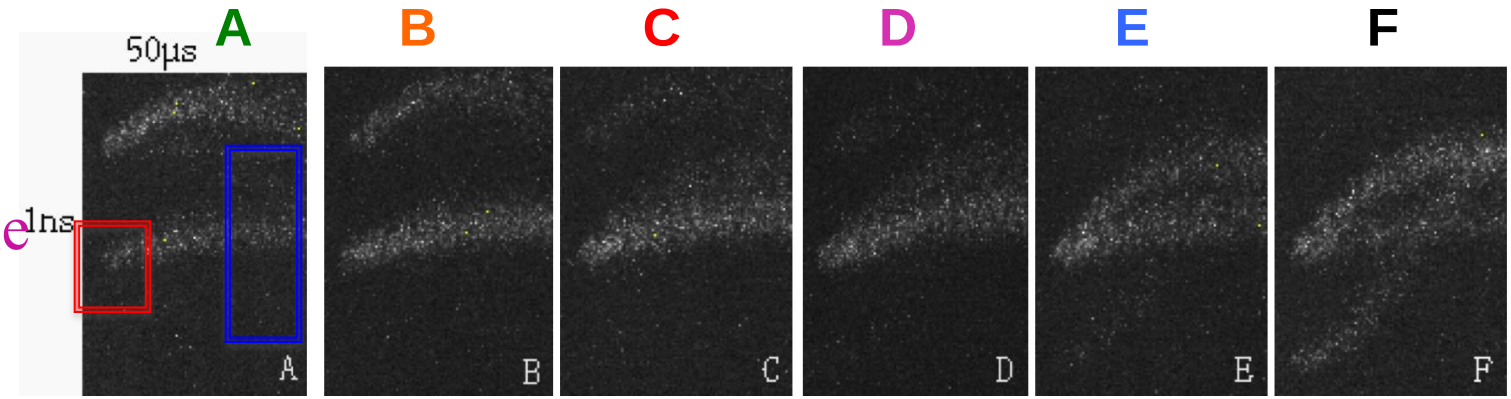


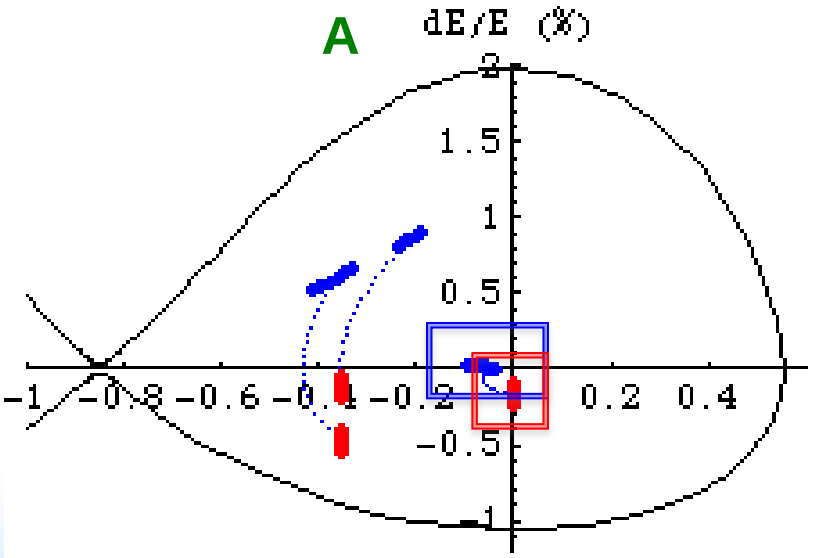


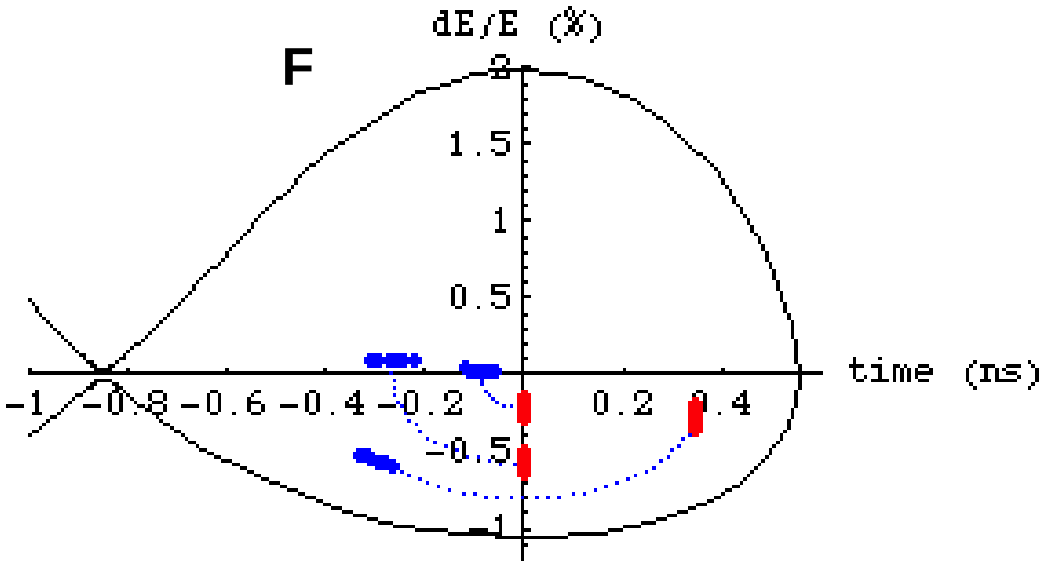
Fluctuation of Longitudinal Beam Profiles

Front

middle







Fluctuation of Longitudinal Beam Profiles

SUMMARY

The injection efficiency had correlation with the bunch structure.

As far as we see, the longitudinal acceptance was large enough.

EXPECTED IMPROVEMENTS

We started discussions for a stabilization of the gate timing.

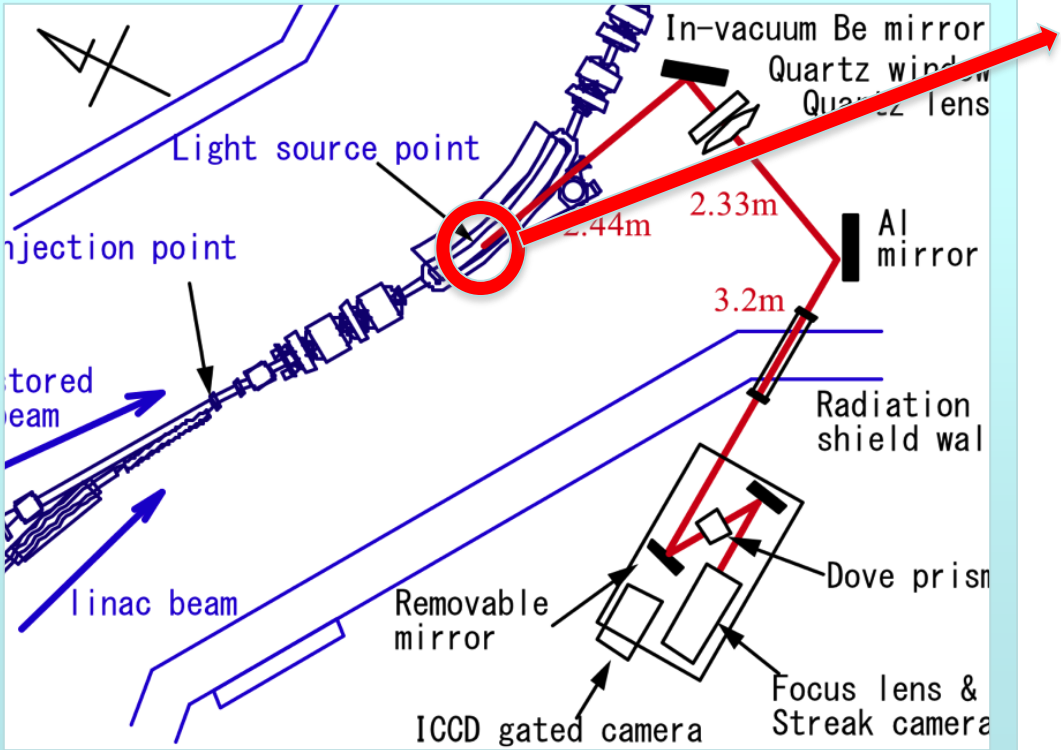
The linac energy was raised by 0.4% after the measurement.

We are developing control system which enables independent energy tuning, one for the Booster and another for NewSUBARU.

THE NEXT IS

a single shot bunch-by-bunch transverse parameter measurement

Measurement of Vertical Parameters



Light Source Point

$\beta_x = 0.7$ m

$\beta_y = 17$ m

$\eta = 0.052$ m

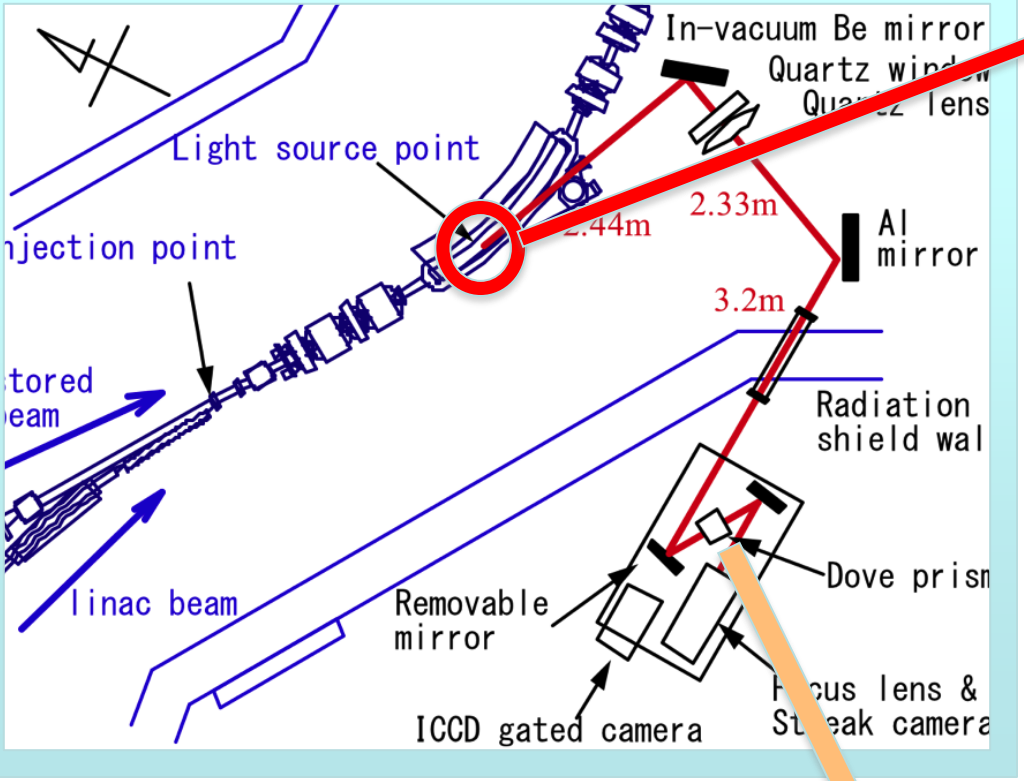
$\Delta E/E = 0.5\%$

→ $\Delta x = 0.26$ mm

$\mathrm{HWHM}^2 = 25\pi\mathrm{nm}^2$

→ FWHM=0.26mm

Measurement of Vertical Parameters



Light Source Point

$\beta_x = 0.7$ m

$\beta_y = 17$ m

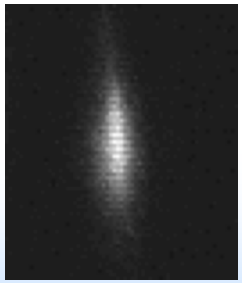
$\eta = 0.052$ m

$\Delta E/E = 0.5\%$

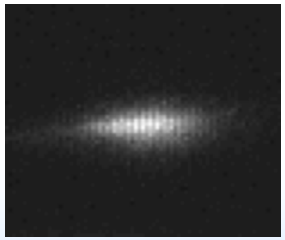
→ $\Delta x = 0.26$ mm

$\mathrm{HWHM}^2 = 25\pi\mathrm{nm}^2$

→ FWHM=0.26mm

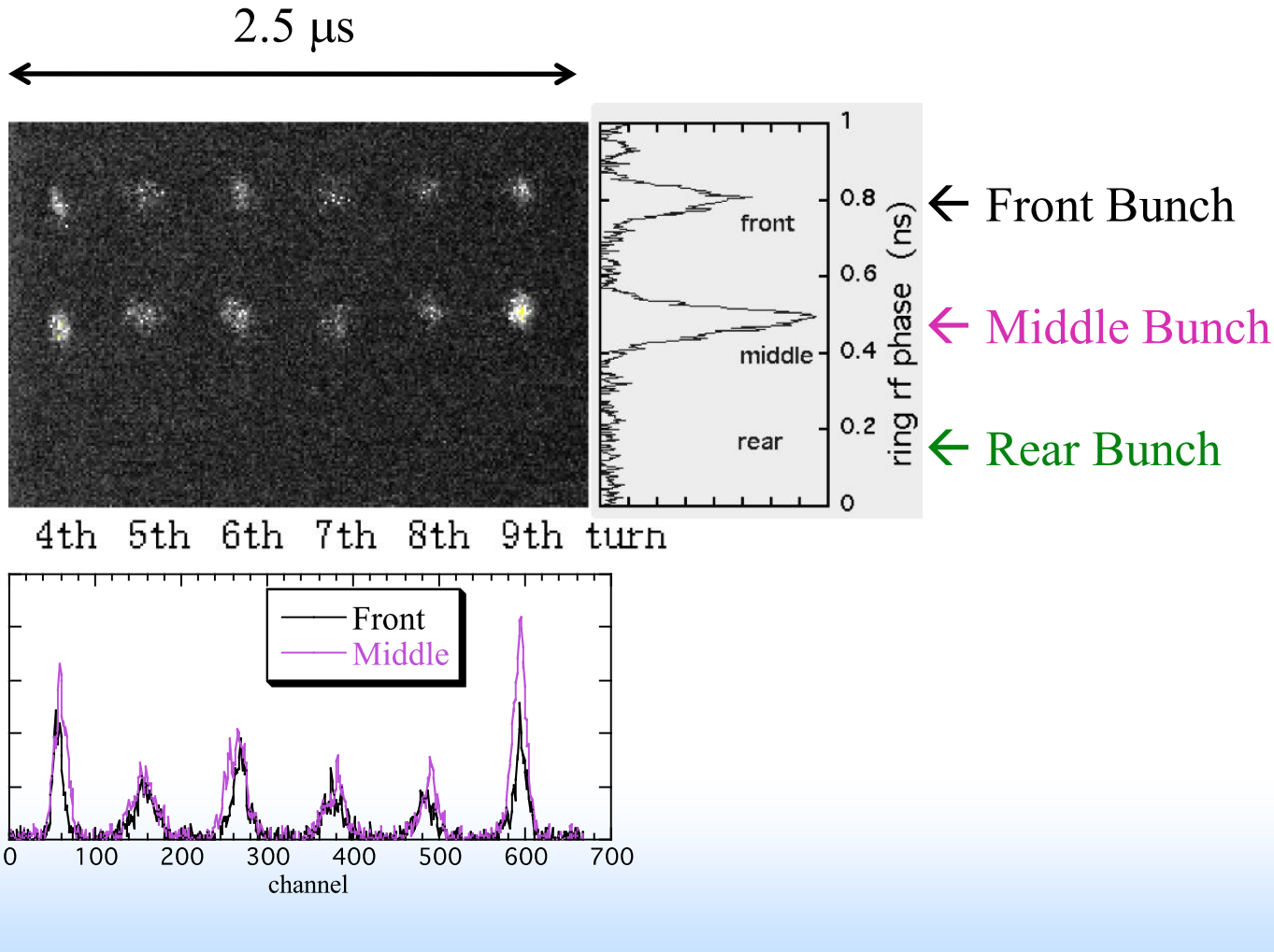


Dove Prism



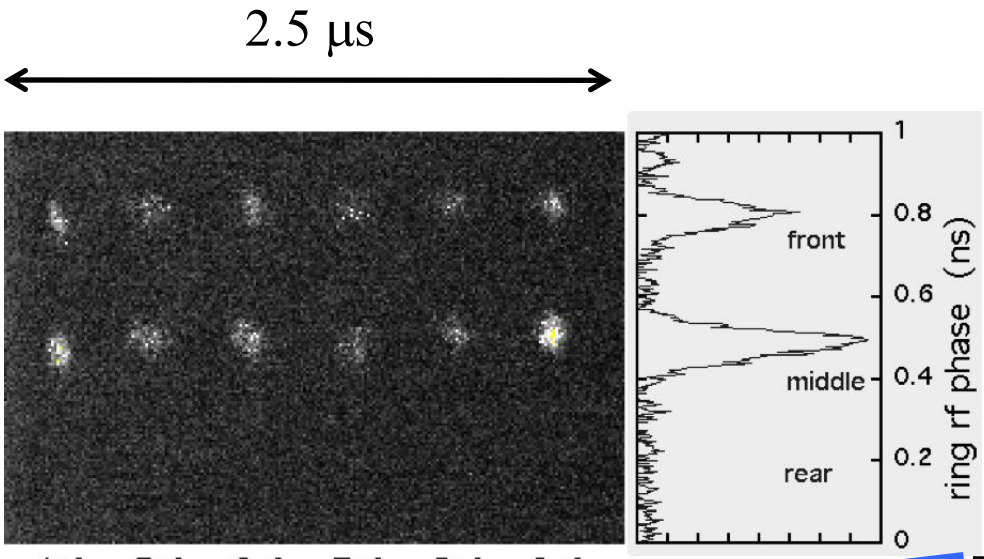
Measurement of Vertical Parameters

Example of single shot data & its analysis



Measurement of Vertical Parameters

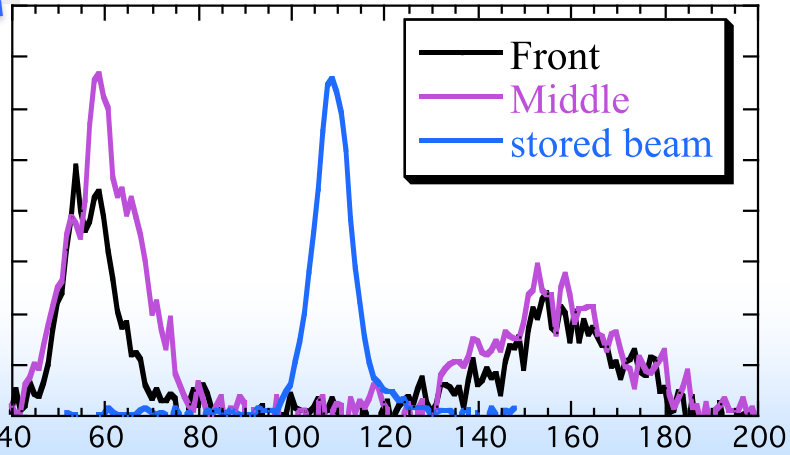
Example of single shot data & its analysis



← Front Bunch

← Middle Bunch

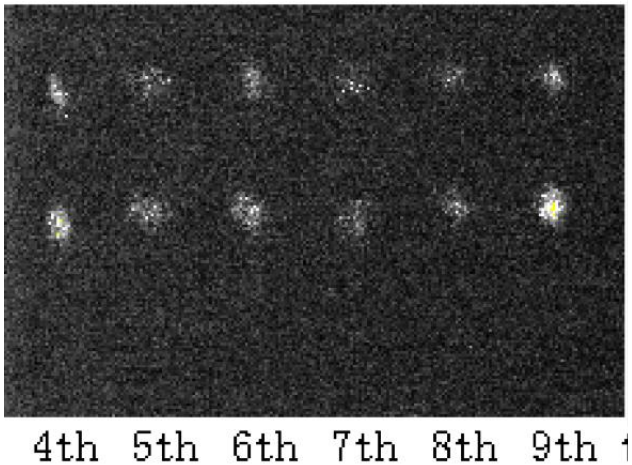
← Rear Bunch

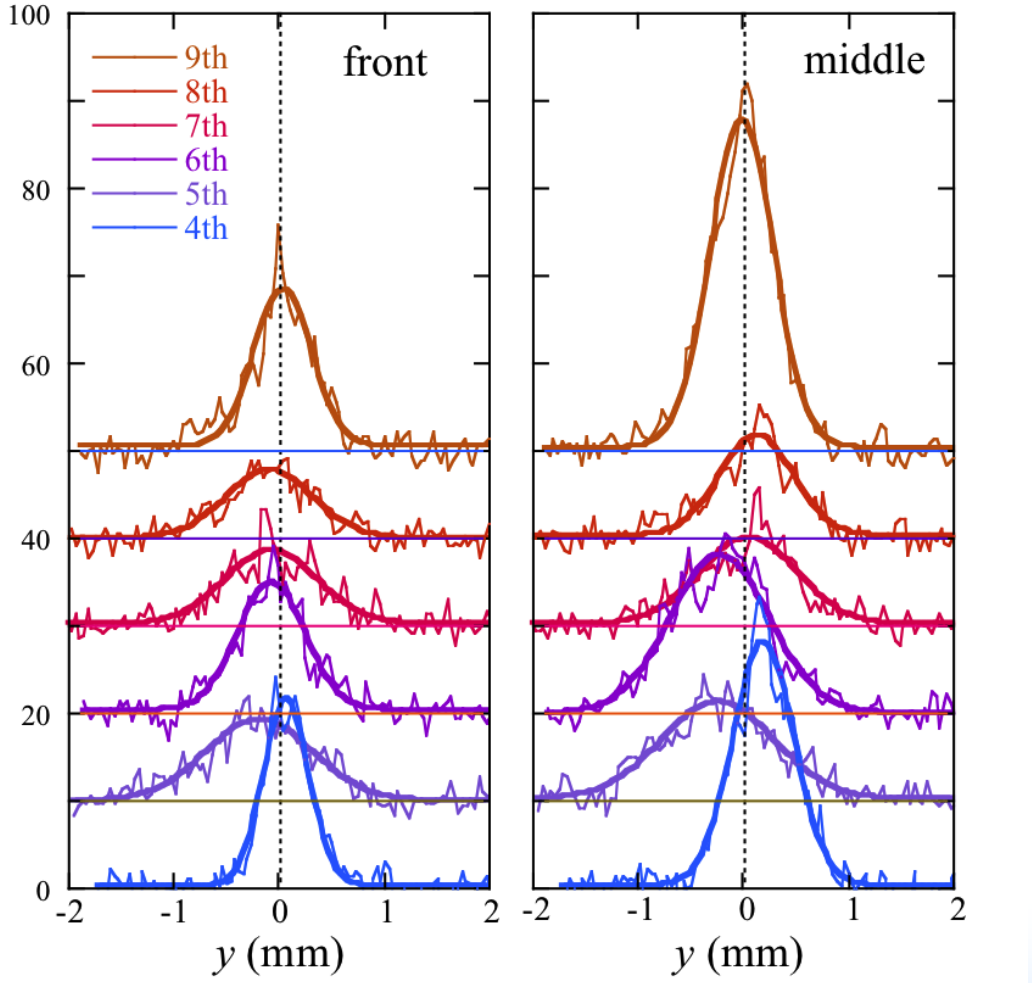


Measurement of Vertical Parameters

Vertical profile

Fitting with Gaussian

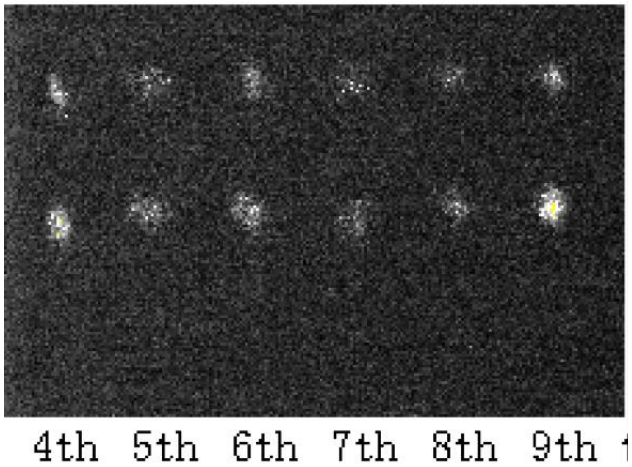




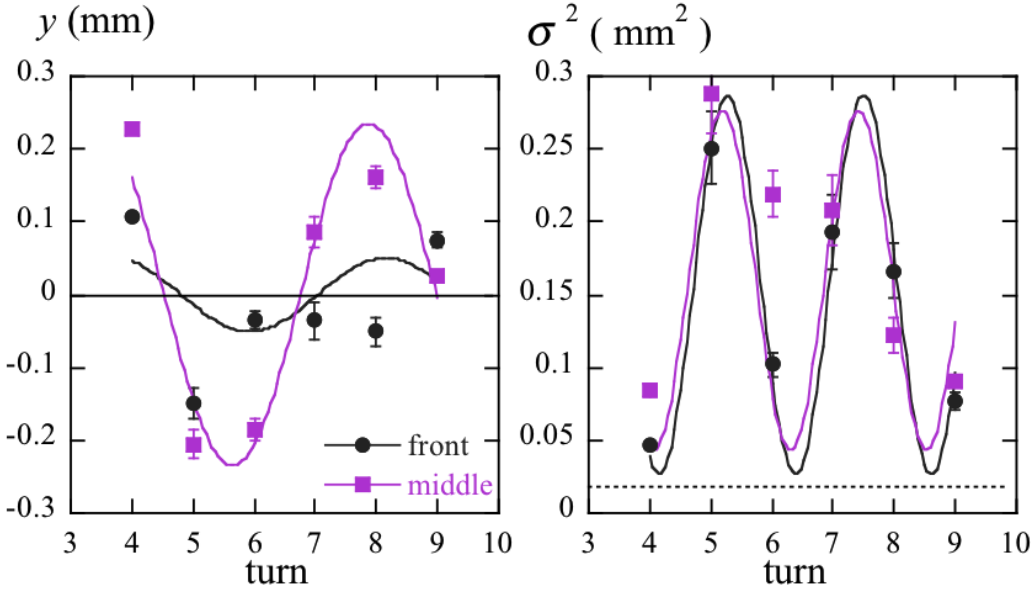
Measurement of Vertical Parameters

Betatron Oscillation

Fitting with sinusoidal function



Dipole Quadrupole

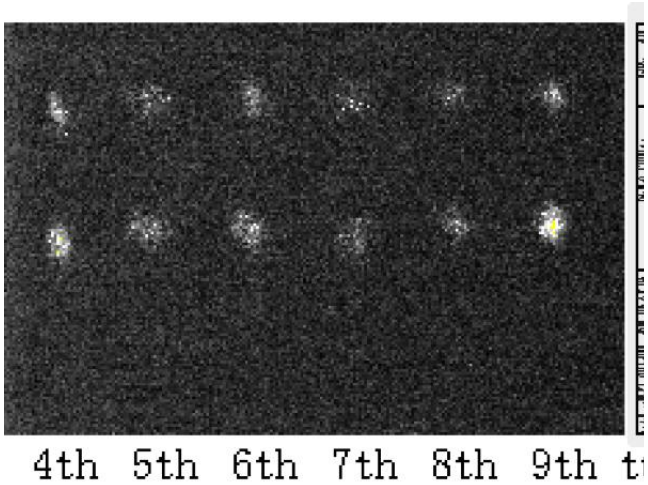


$$y = A_0 + A_S \sin(2\pi\Delta\nu_y N) + A_C \cos(2\pi\Delta\nu_y N)$$

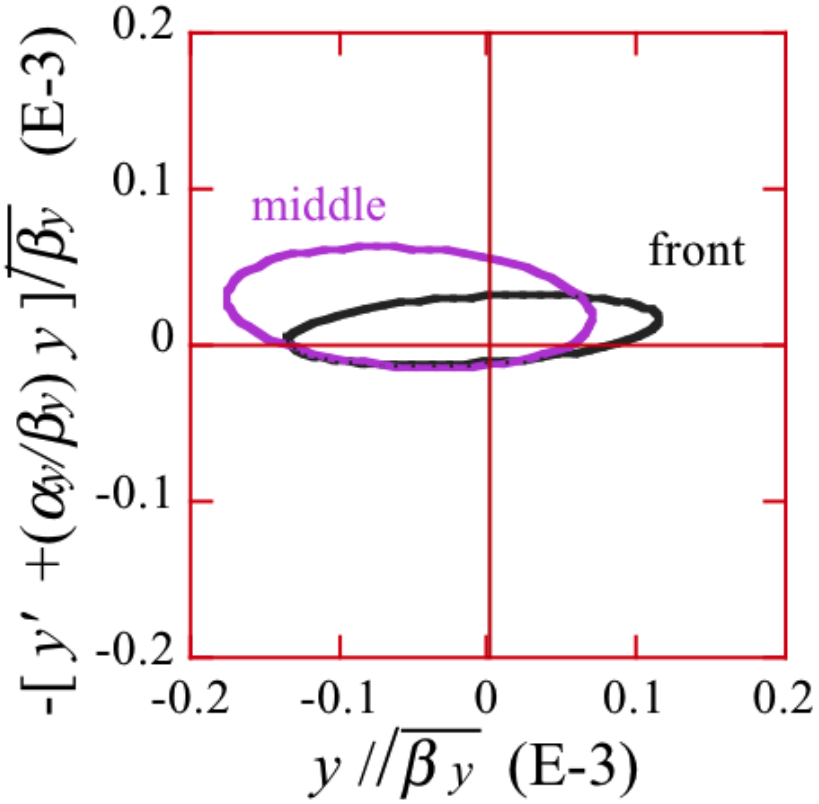
$$\sigma^2 = B_0 + B_S \sin(4\pi\Delta\nu_y N) + B_C \cos(4\pi\Delta\nu_y N)$$

Measurement of Vertical Parameters

Reproduce ellipse at the injection point



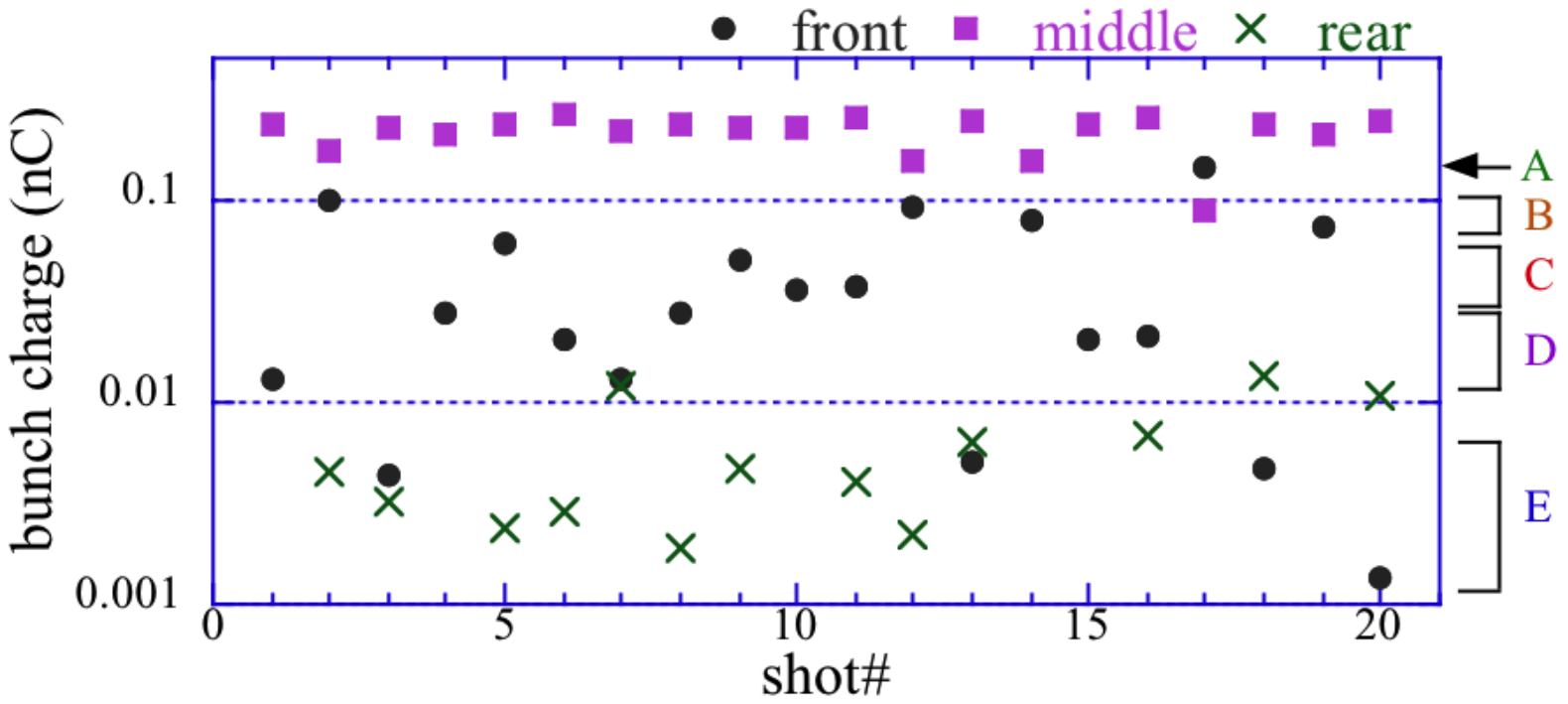
Normalized phase space of vertical betatron oscillation



Fluctuation of Vertical Parameters

Measurement of 20 shots

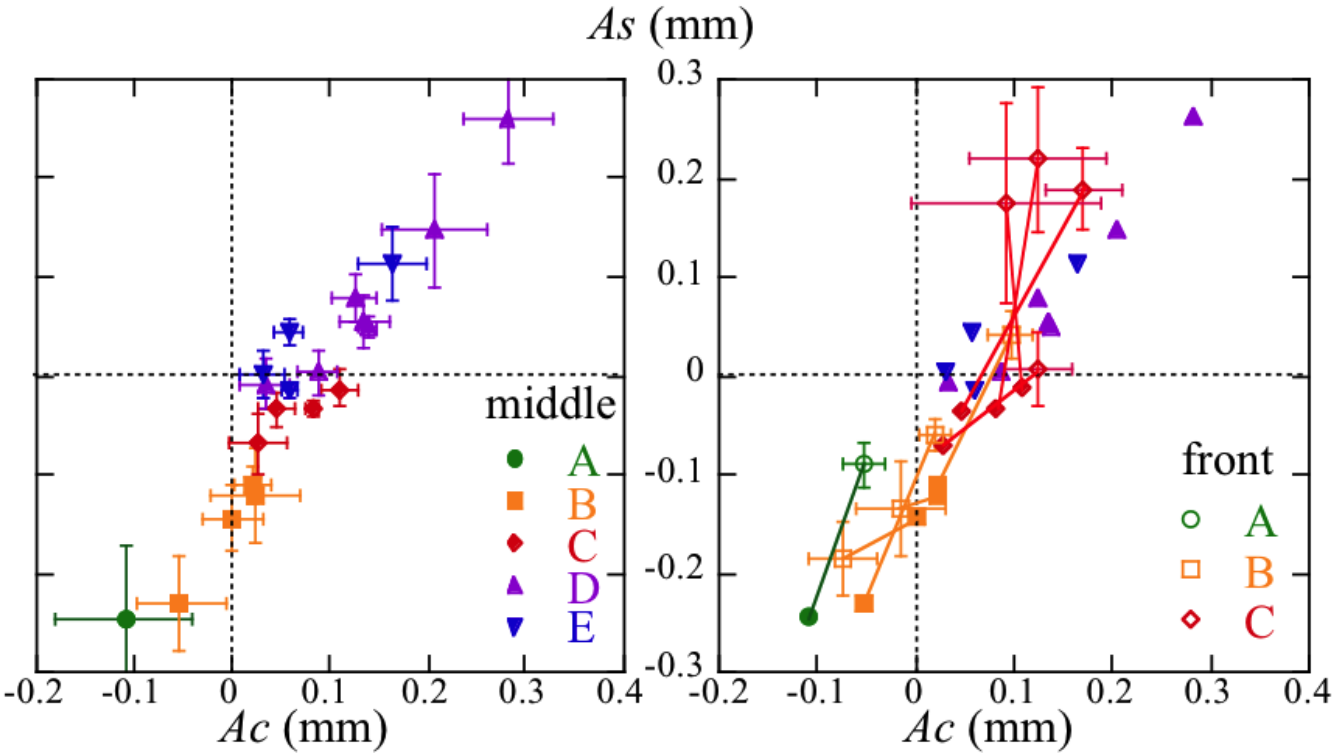
Fluctuation of bunch charge



Fluctuation of Vertical Parameters

Measurement of 20 shots

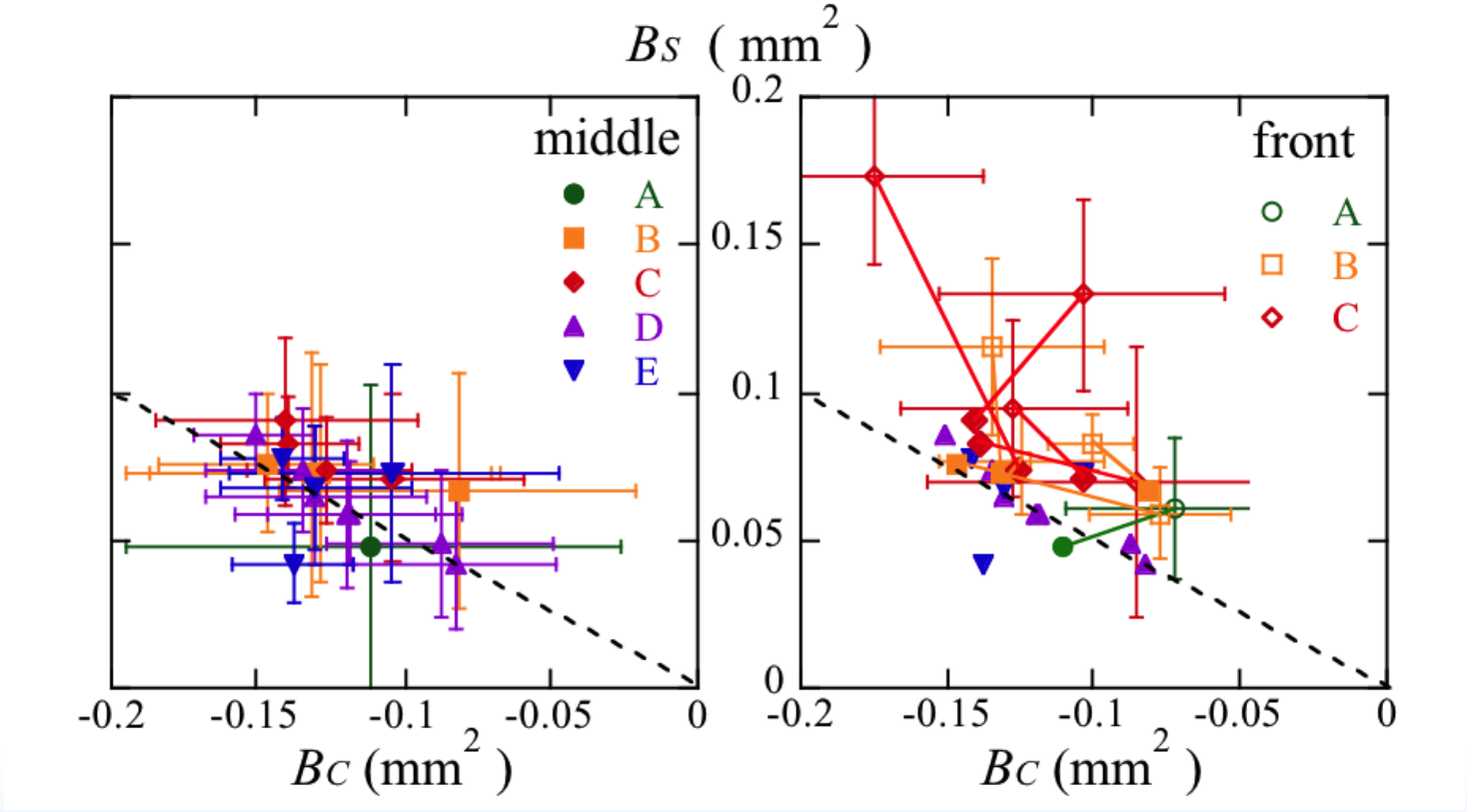
Fluctuation of dipole oscillation; *Ac* & *As*



Fluctuation of Vertical Parameters

Measurement of 20 shots

Fluctuation of quadrupole oscillation; *Bc* & *Bs*



Fluctuation of Vertical Parameters

SUMMARY

The transverse (vertical) parameters had a dependence on the bunch structure.

Although we did not identify the source,

It is possible that the horizontal has a similar dependence.

THE NEXT

The injection efficiency is less sensitive to the vertical parameter.

This was the step for the measurement of more important horizontal parameters.

SUMMARY

We succeeded in the single shot measurement of the bunch-by-bunch ellipse of the vertical betatron oscillation.

However, there exist scope for improvements.

Our better understanding of the injection process

and the linac beam parameters

would provide an opportunity to solve problems of injection to NewSUBARU in a systematic way