

Beam injection study at Aichi SR and UVSOR-III (Pulsed multipole Injection)

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Content

1. What are Aichi SR & UVSOR ?
2. Injection method
3. (Experimental Result) Multipole Injection at UVSOR
4. (Calculation) Multipole Injection at Aichi SR

Aichi SR & UVSOR

Aichi SR

Energy : 1.2 GeV

Circumference : 72 m (240 ns)

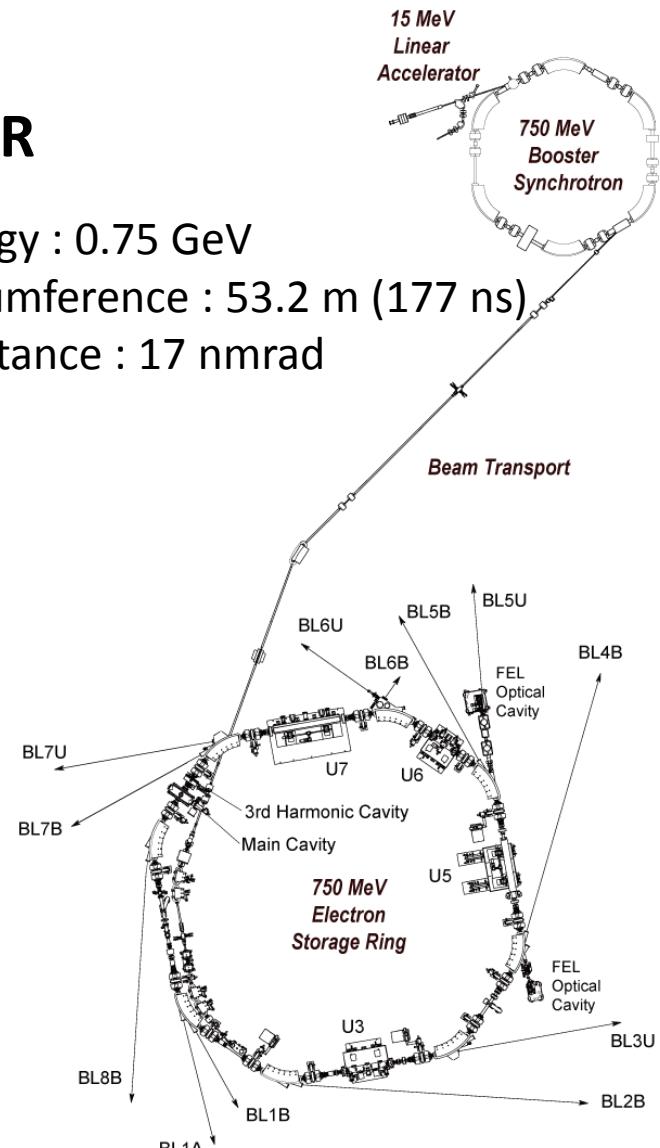
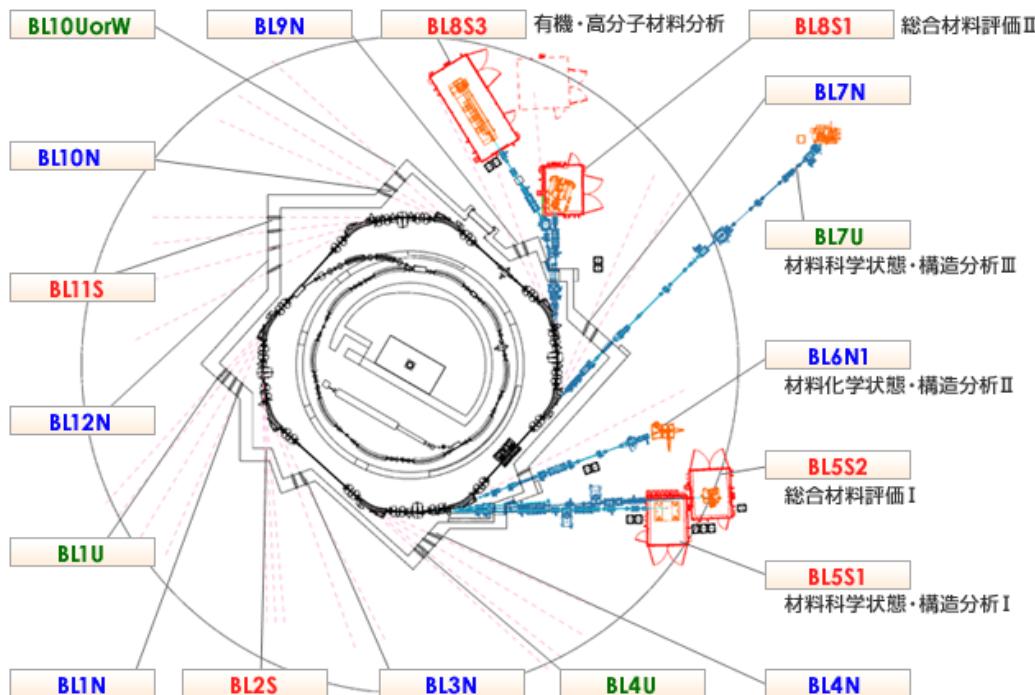
Emittance : 53 nmrad

UVSOR

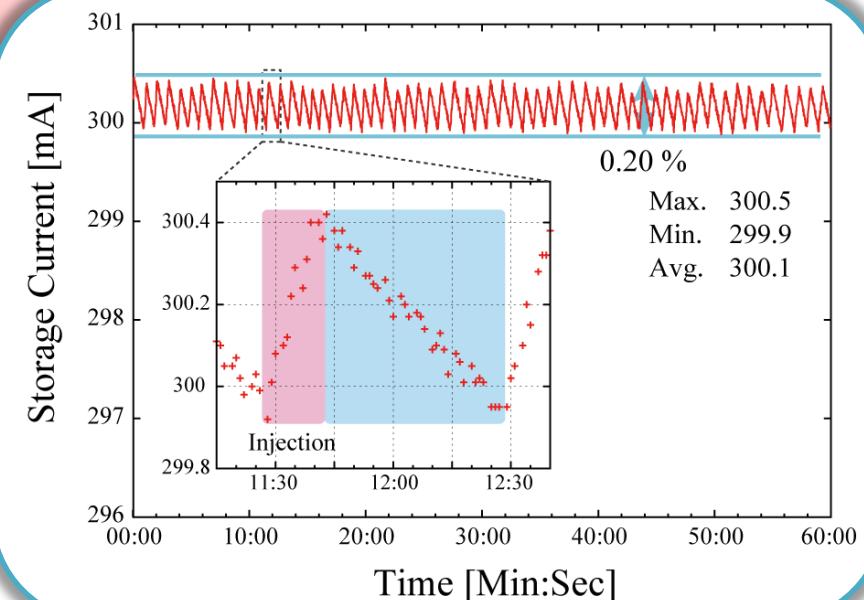
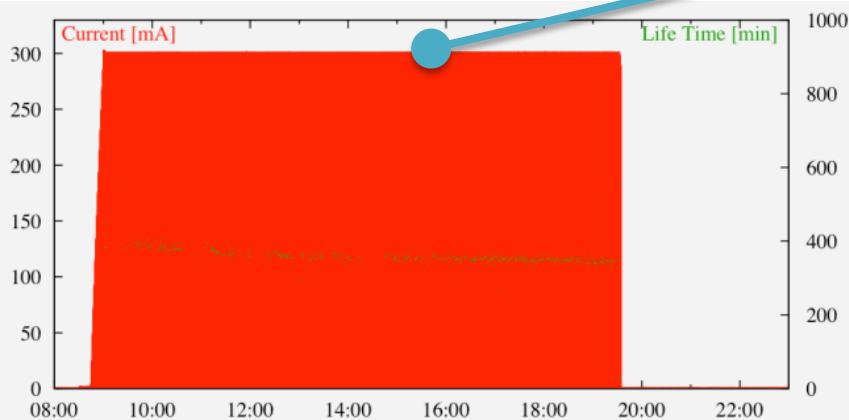
Energy : 0.75 GeV

Circumference : 53.2 m (177 ns)

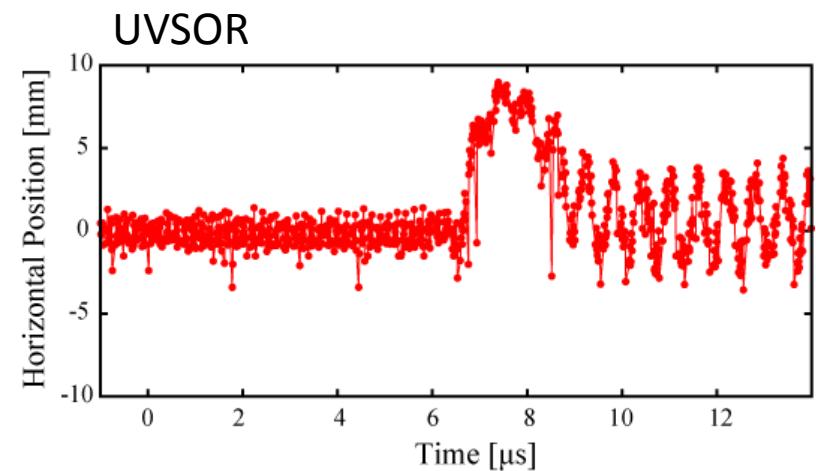
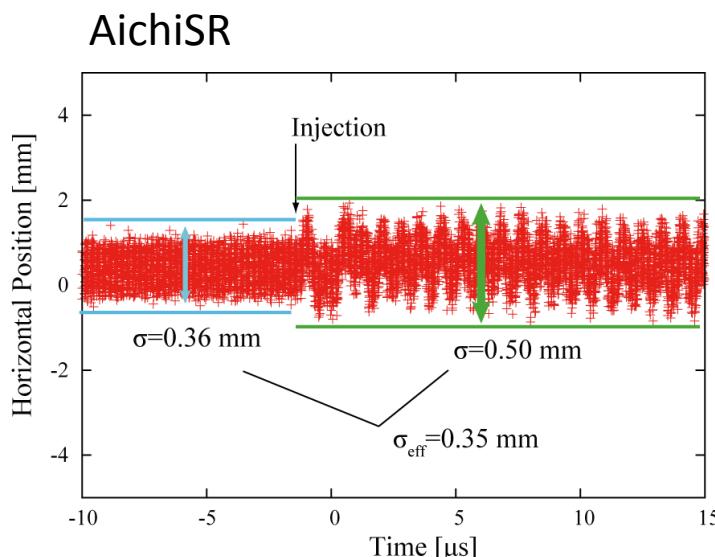
Emittance : 17 nmrad



Top-up Operation

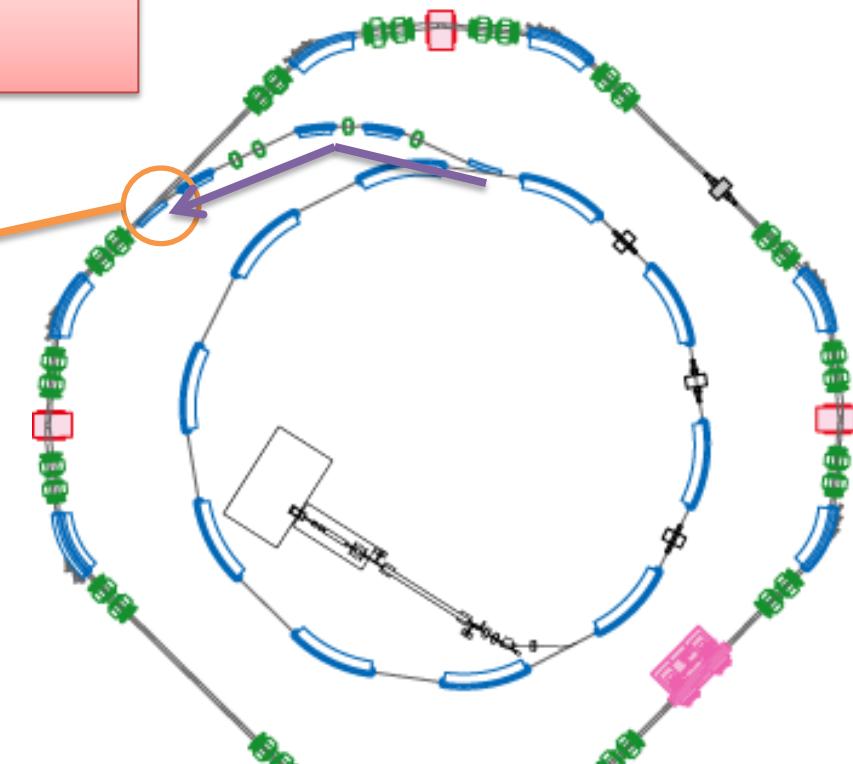
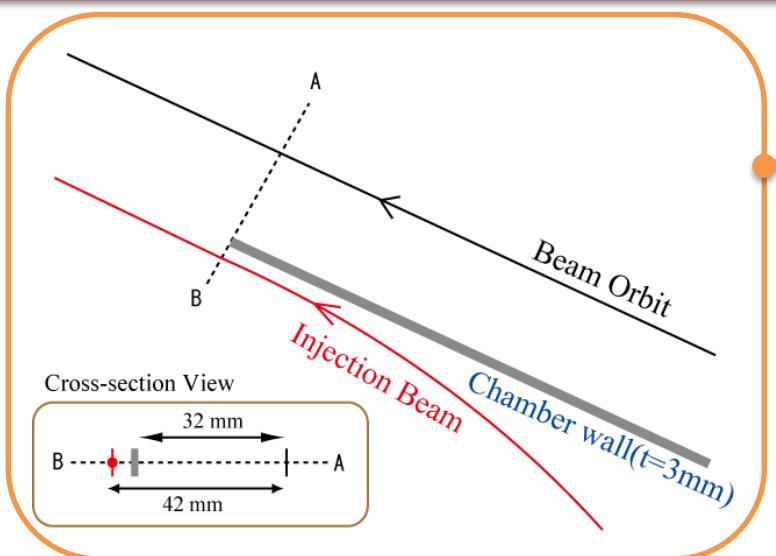


Coherent Oscillations at beam injection

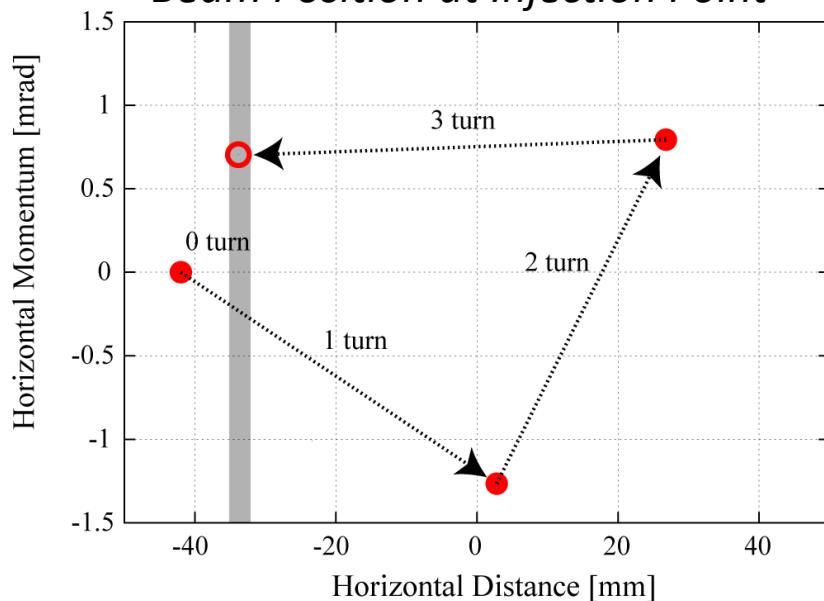


We have to minimize these oscillations.

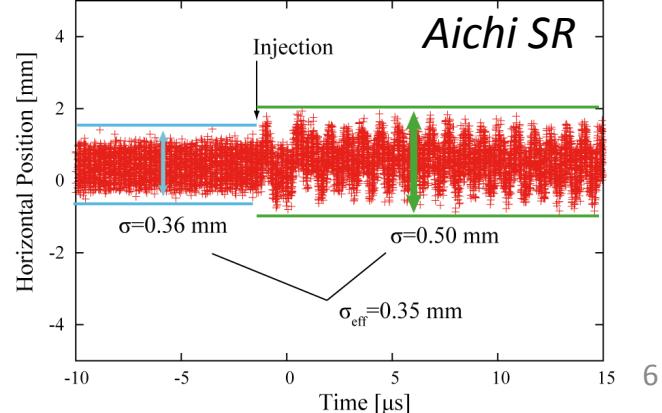
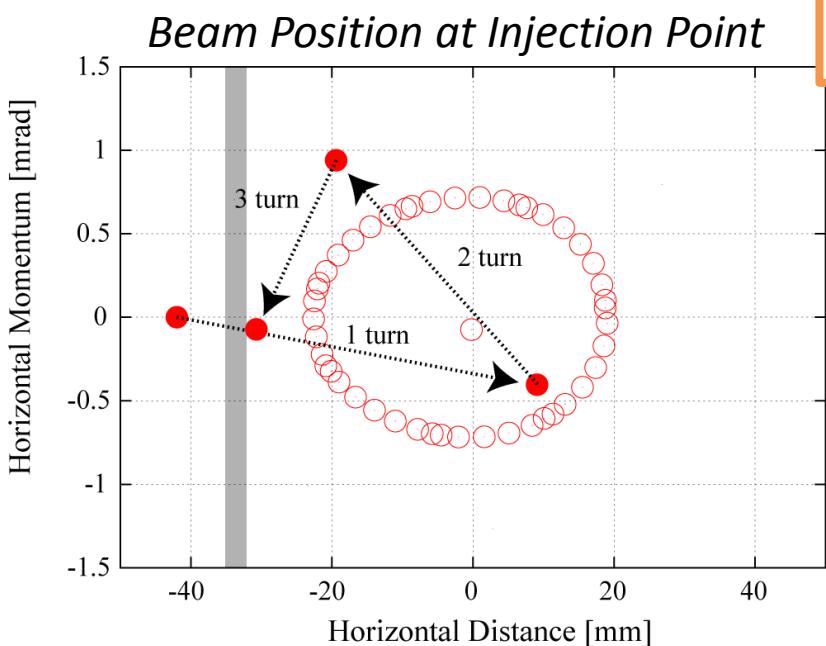
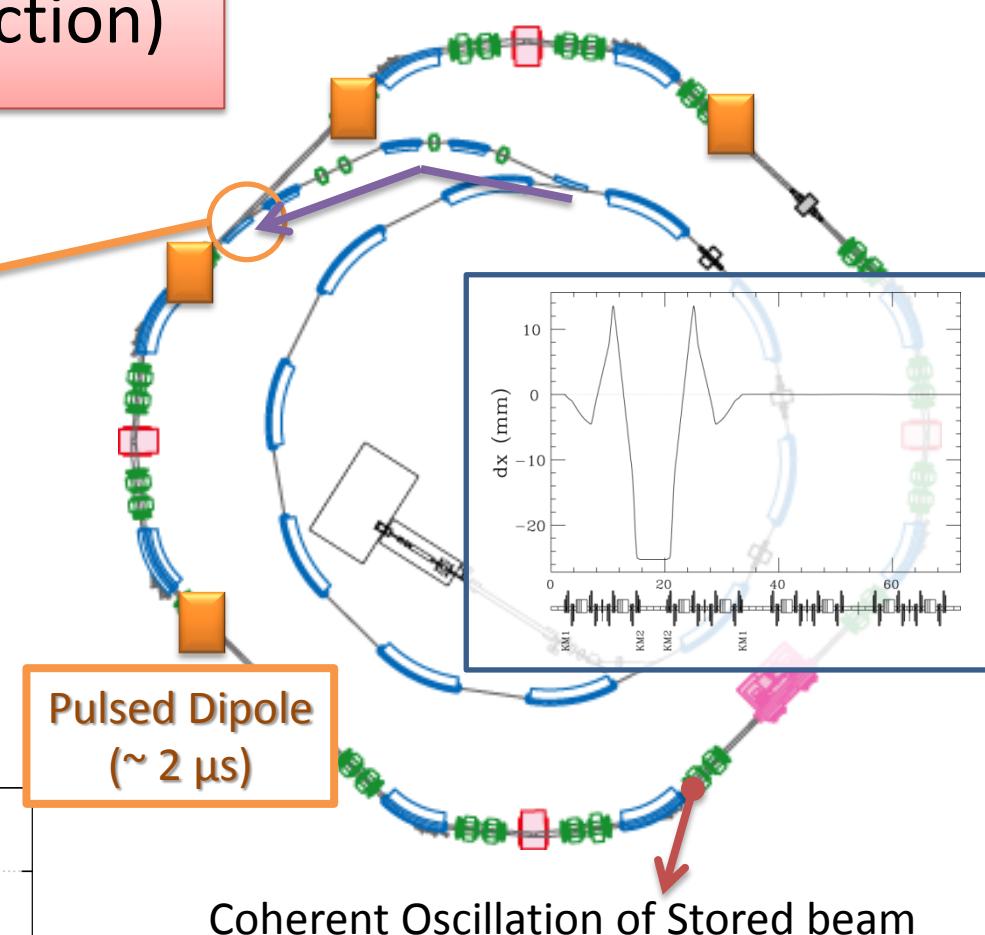
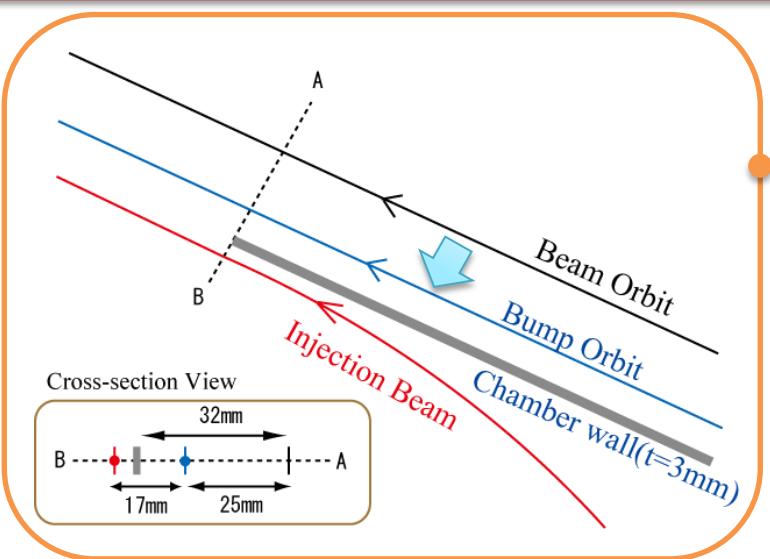
Injection Method



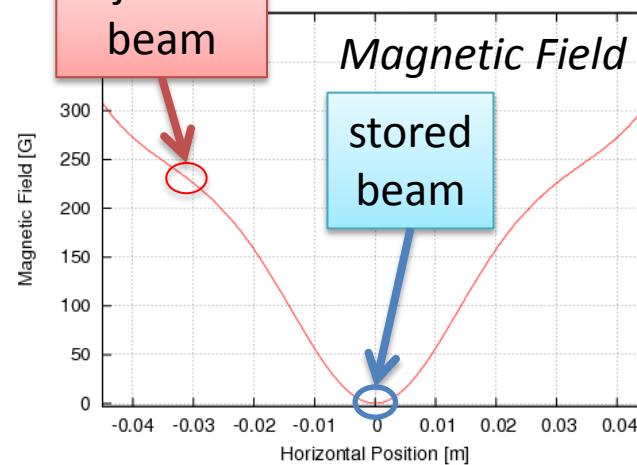
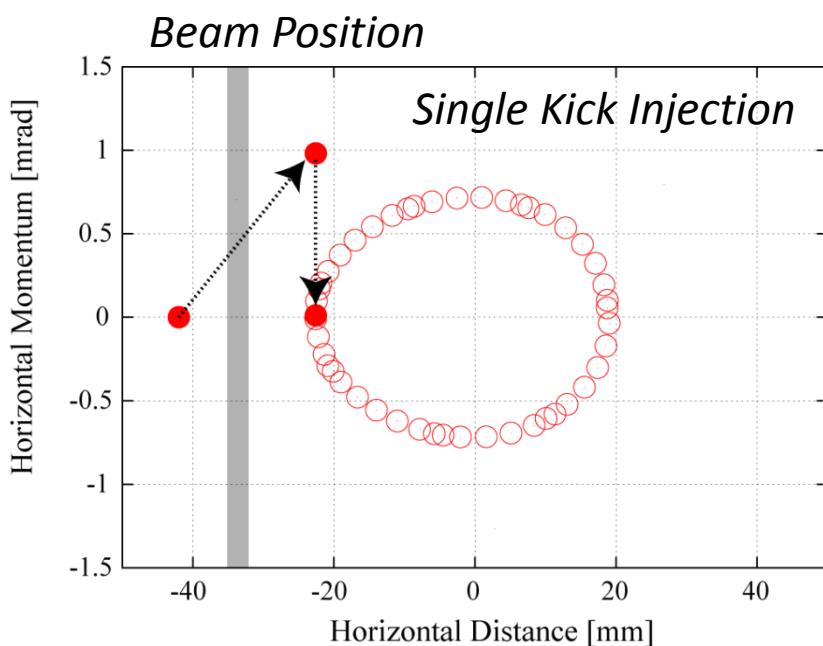
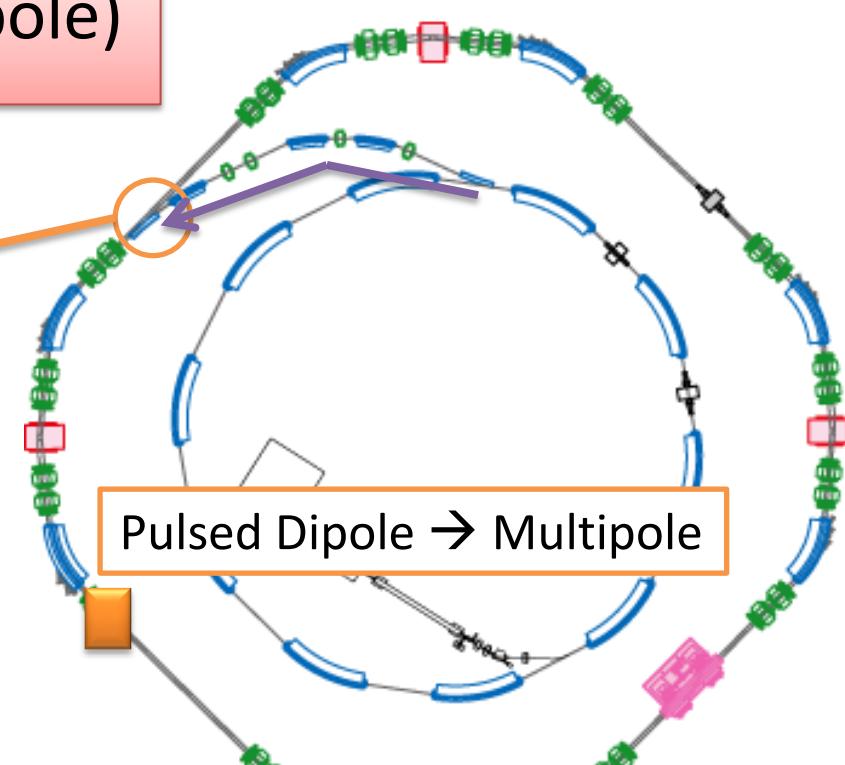
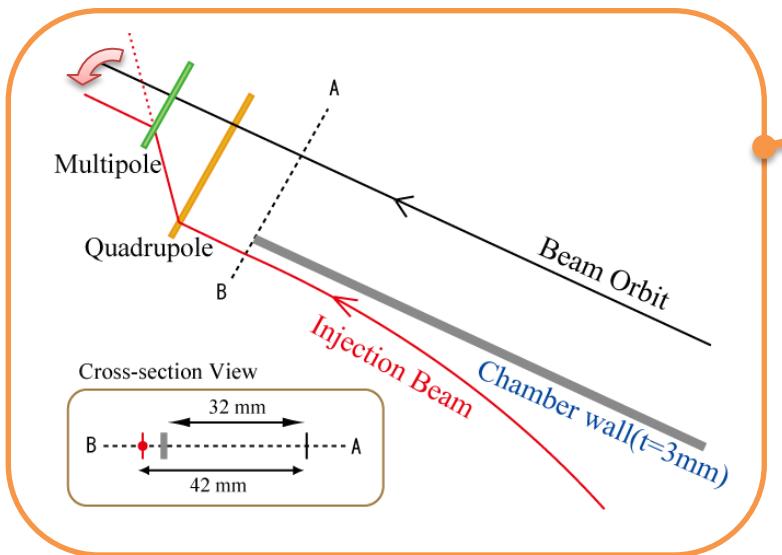
Beam Position at Injection Point



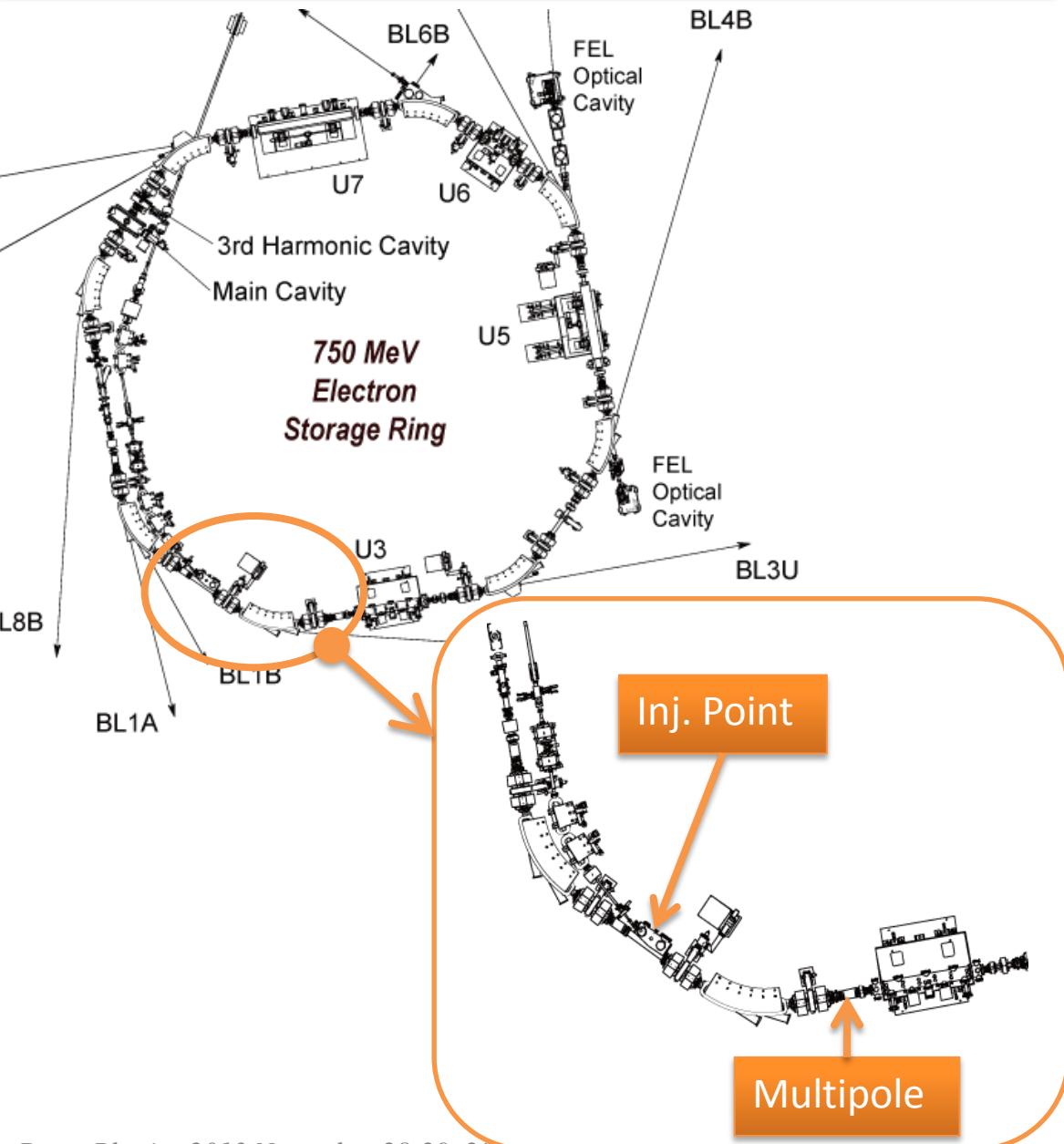
Injection Method (Bump Injection)



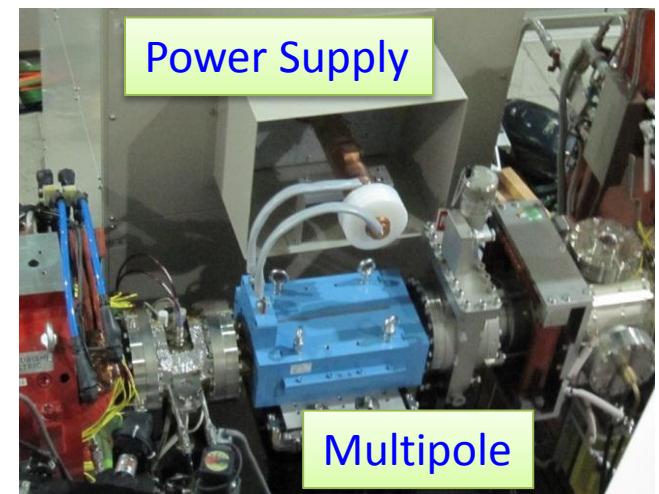
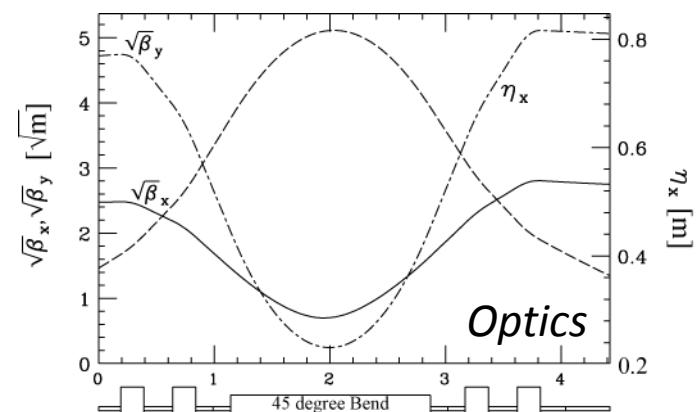
Injection Method (Pulsed Multipole)



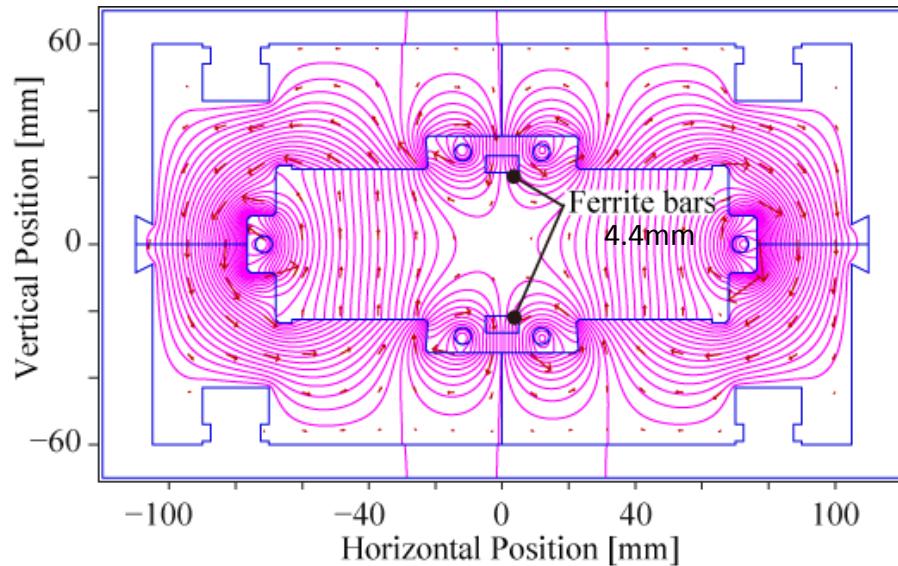
Multipole Injection at UVSOR (Machine condition)



Electron energy (MeV) : 750
Circumference (m) : 53.2
Natural emittance (nm rad) : 16.9
Natural energy spread : 5.4×10^{-4}
Horizontal Tune : 3.613
Vertical Tune : 3.261



Multipole Injection at UVSOR (Magnet condition)



Sextupole Magnet

Core Length : 240 mm

Vertical Gap : 45 mm

Horizontal Gap : 136 mm

Inductance : $2.15 \mu\text{H}$ (+ $1.8 \mu\text{H}$)

York : laminated silicon steel ($t = 0.2\text{mm}$)

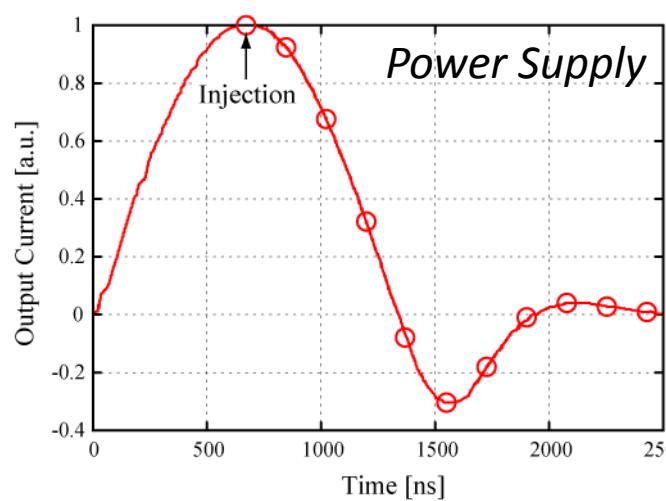
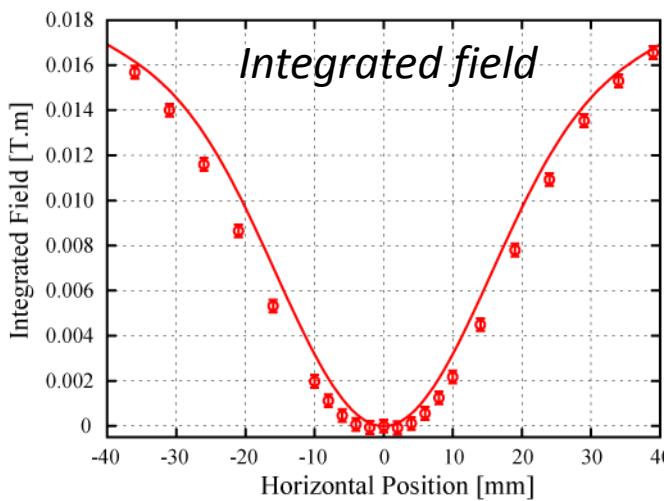
Power Supply

Max. Peak Current : 2400 A

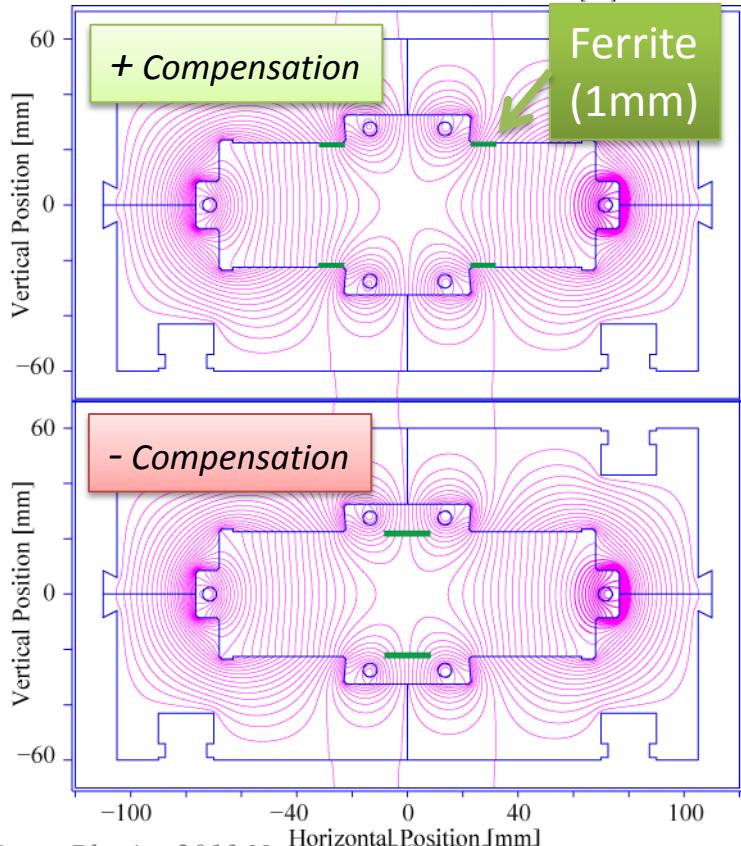
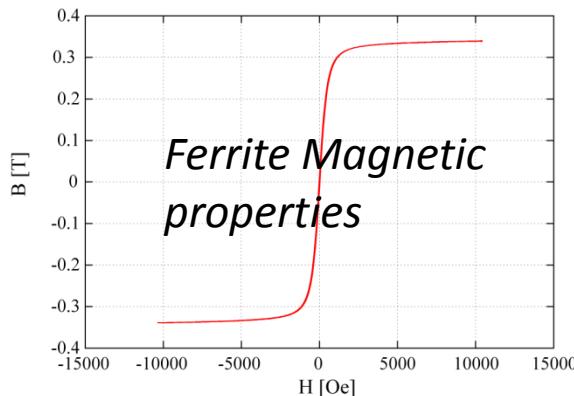
Max. Charging Voltage : 22 kV

Pulse period : $1.33 \mu\text{s}$

Repetition rate : 3 pps



Multipole Injection at UVSOR (Compensation of Residual Field)



EMI吸収シート EMI ABSORPTION SHEET / MAB



ソフトフェライトを樹脂に配合したフレキシブルシート
Flexible sheet consists of resin with soft ferrite filler

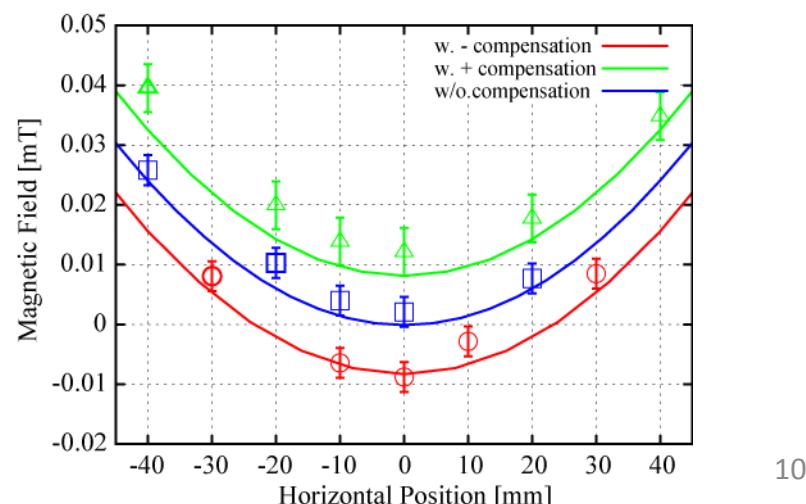
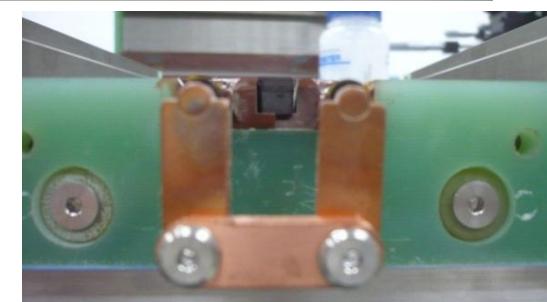
特長 Feature

- 厚さ0.4~4.0mmと豊富なバリエーションを取り揃えています。
- 柔軟性をもち、取り扱いが容易です。

- Sheet thickness, 0.4 - 4.0mm are available.
- Flexible and easy handling.

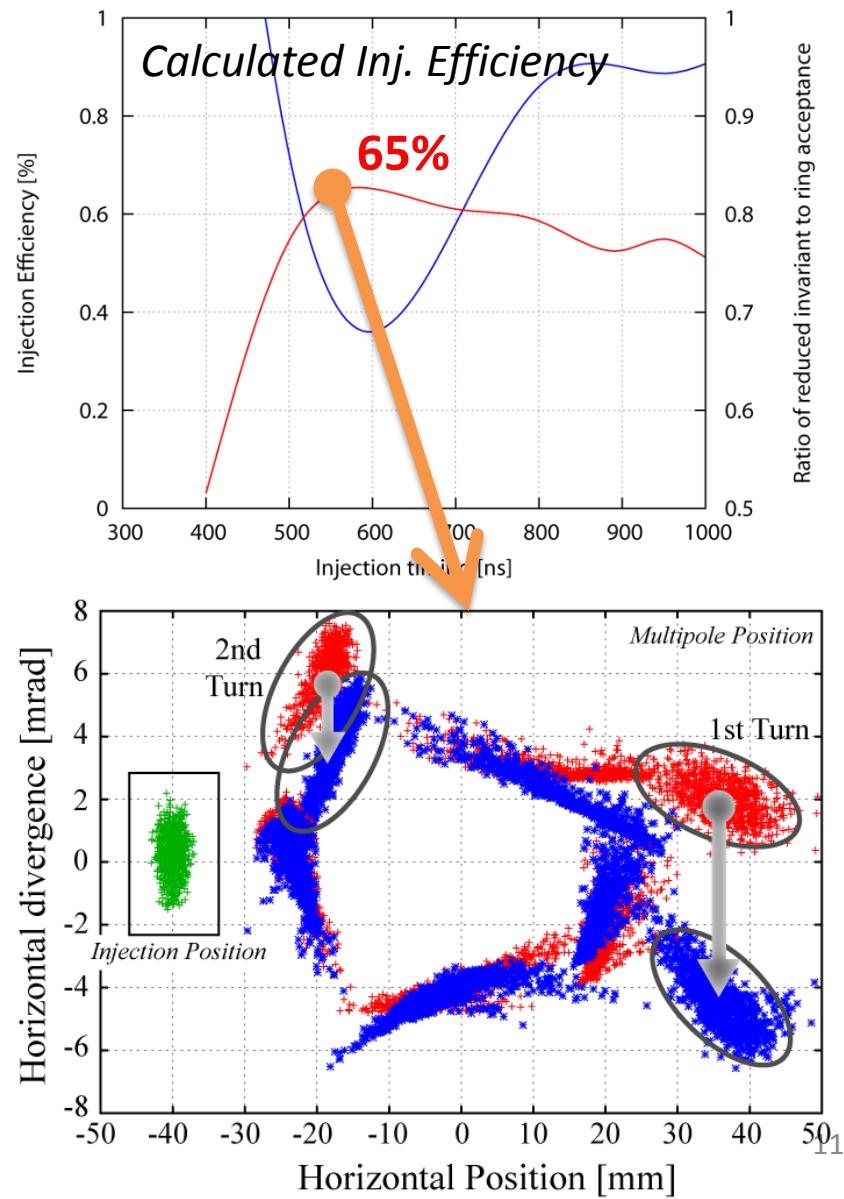
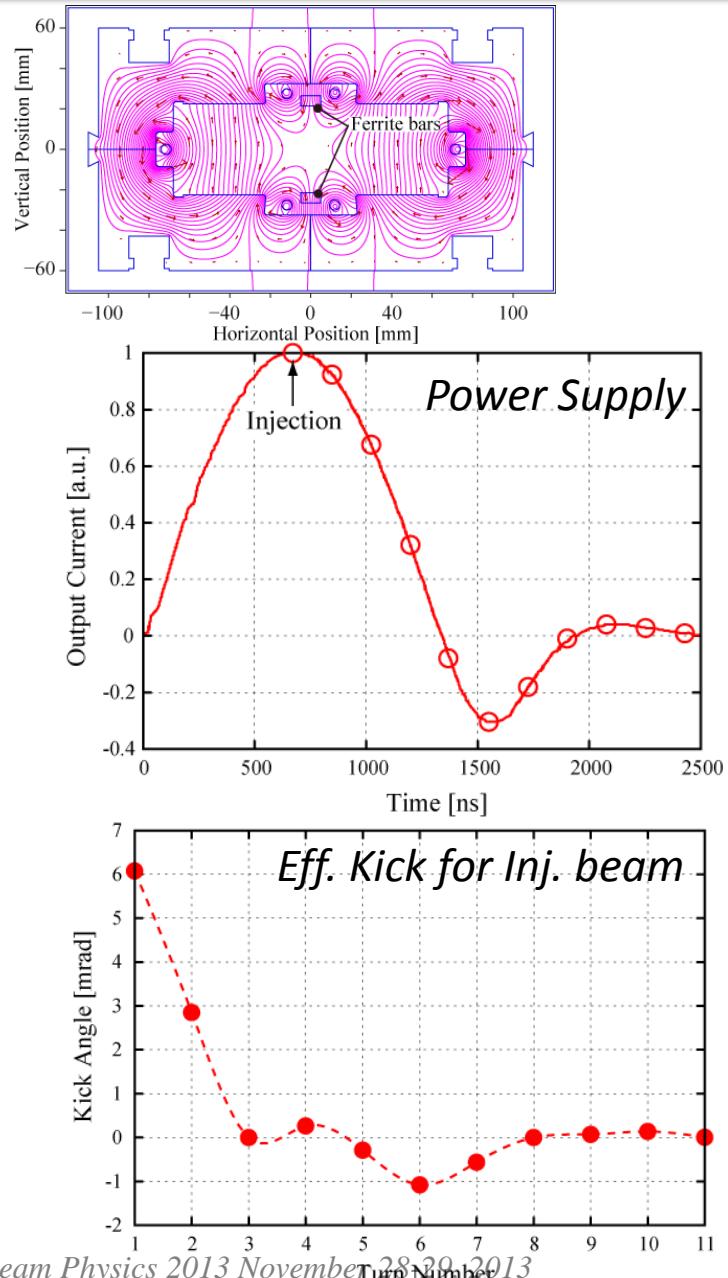
材料 Material

- ソフトフェライト+樹脂
- Soft ferrite + resin



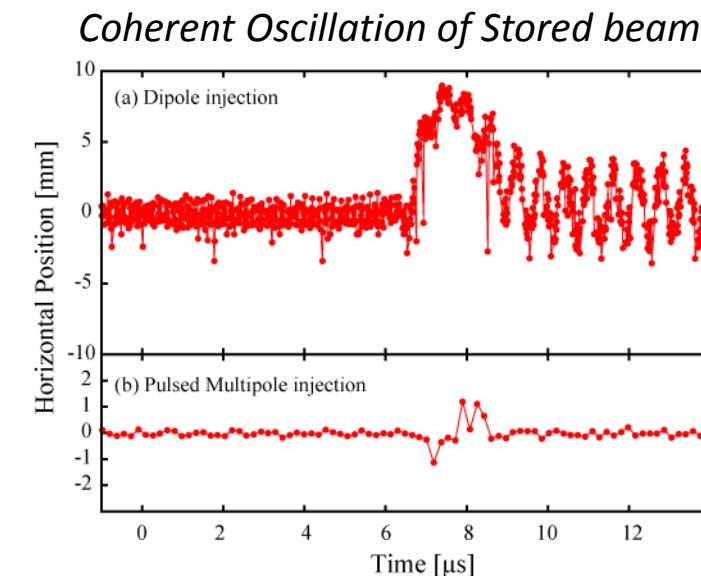
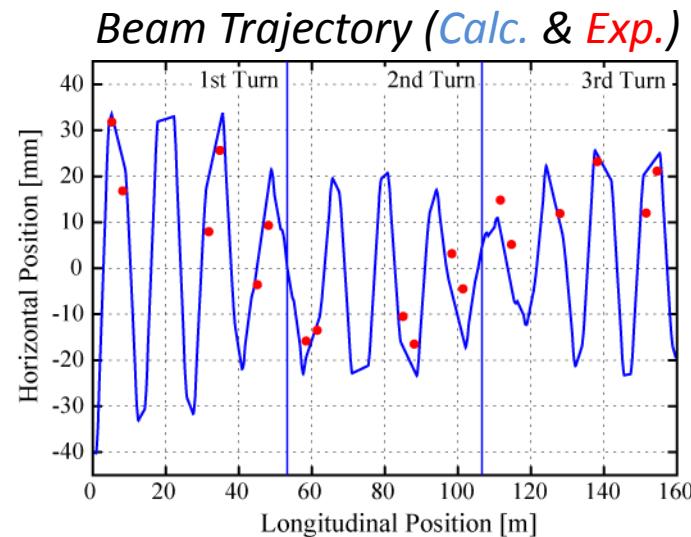
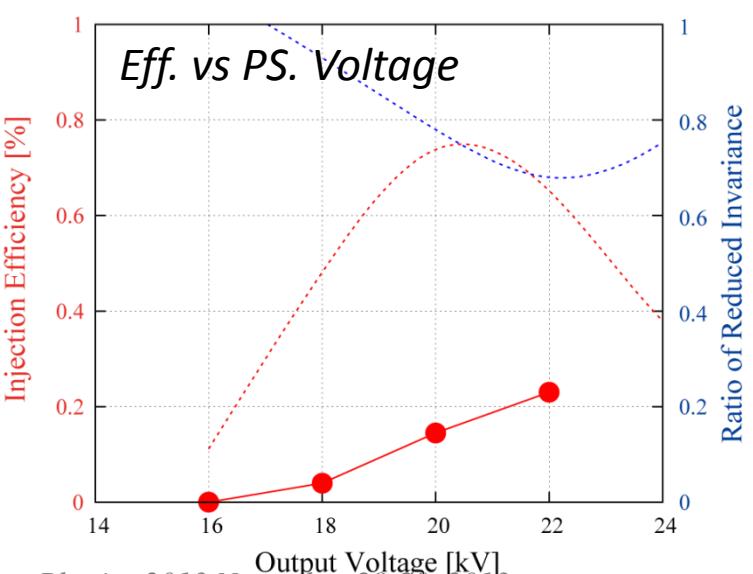
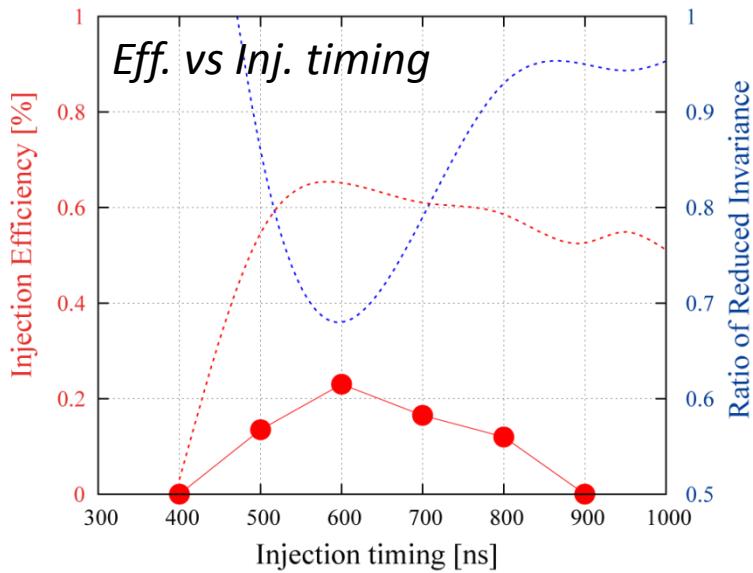
Multipole Injection at UVSOR (Calculation)

Horizontal Tune : 3.613
Vertical Tune : 3.261



Multipole Injection at UVSOR (Experimental Result)

Max. Inj. Eff. : **23%** (Cal.65%)



For Injection Efficiency,

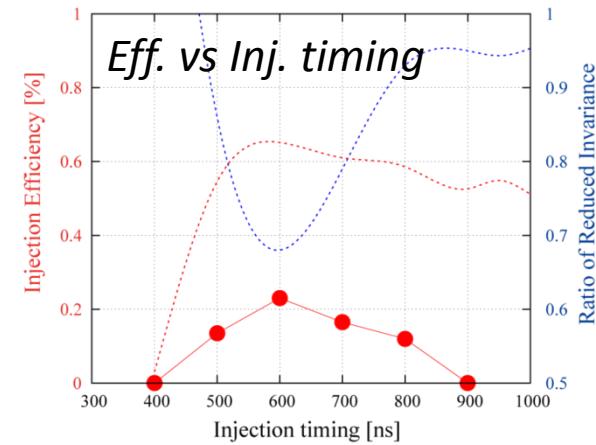
The calculated and experimental curves are similar.

There is a discrepancy in the absolute value.

Calculation : 65%

Experimental : 23 %

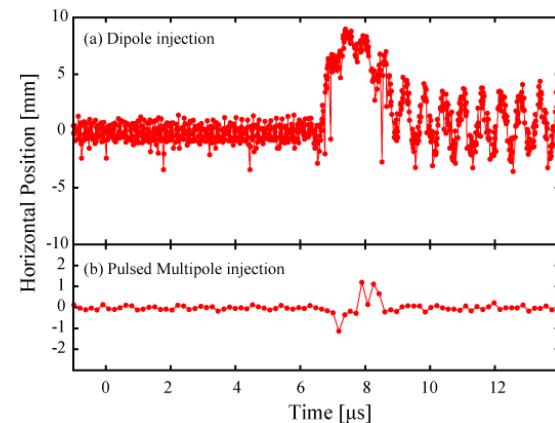
→ *Is quality of injection beam worse ?*



For Coherent Oscillations of stored beam,

we have observed the drastic suppression.

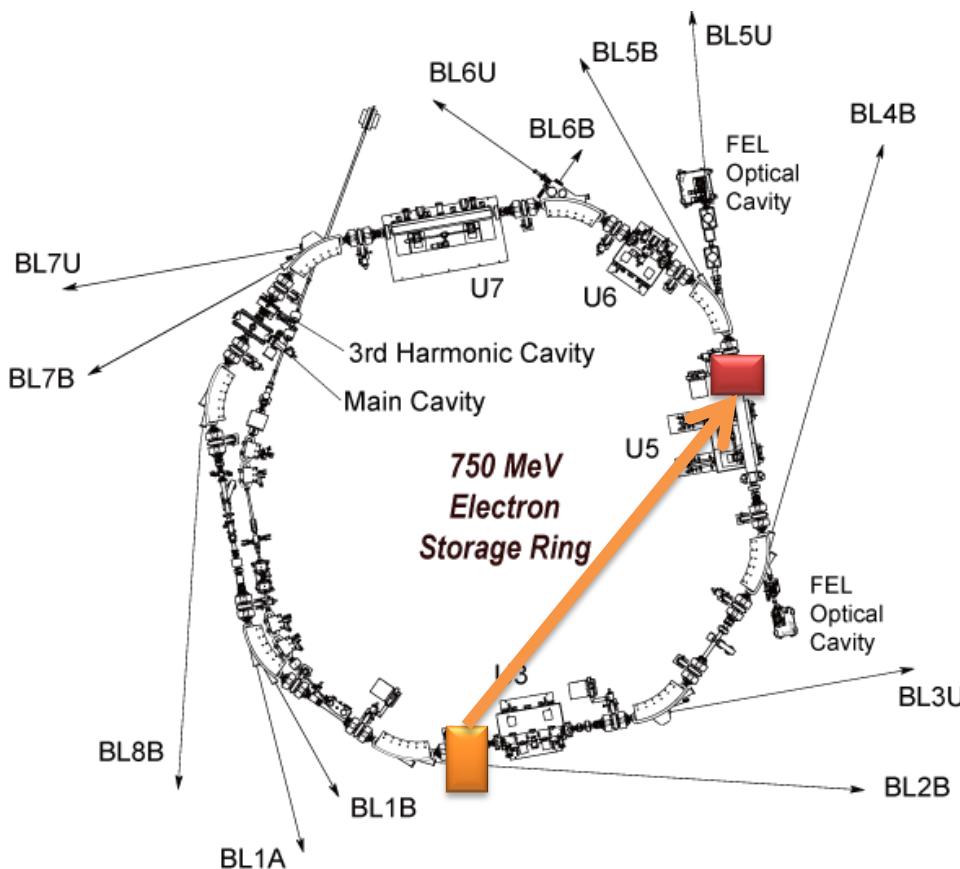
→ *Field compensation using thin ferrite sheets
is successfully demonstrated.*



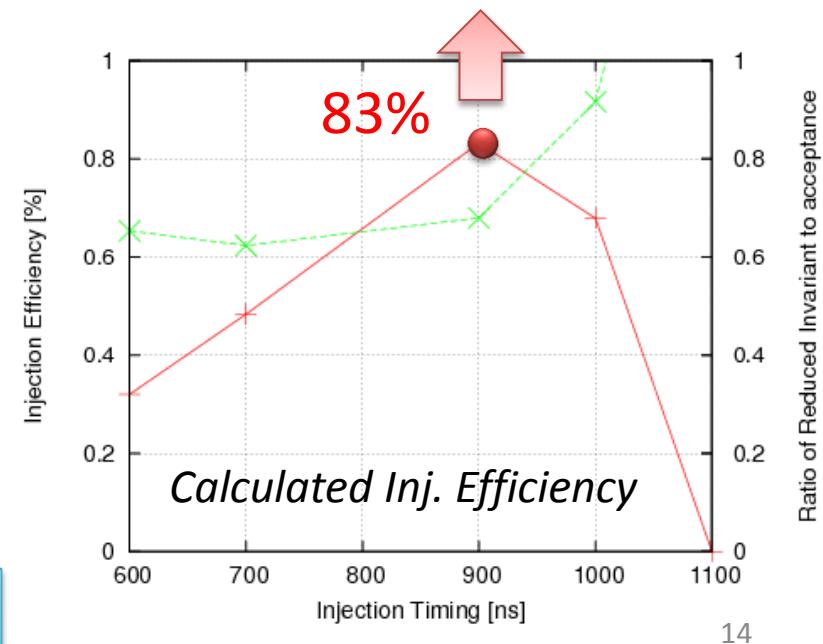
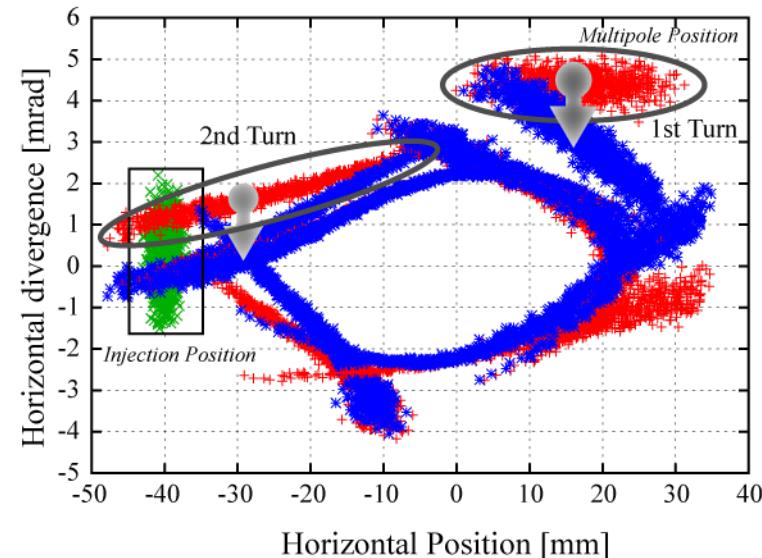
Multipole Injection at UVSOR (Prospects)

Max. Inj. Eff. : **23%** (Cal.65%)

To improve Inj. Efficiency,
-> Change the Multipole Position
(S3U → U5D) ?



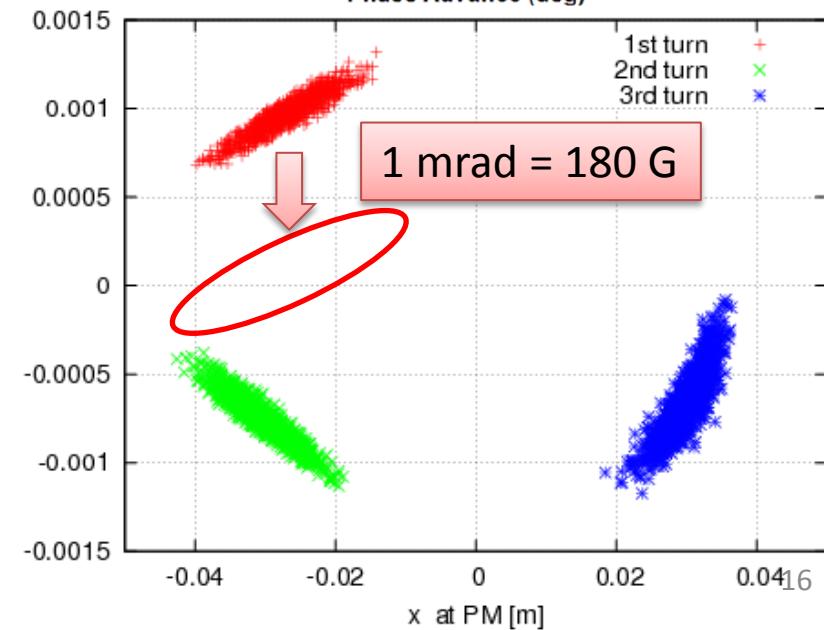
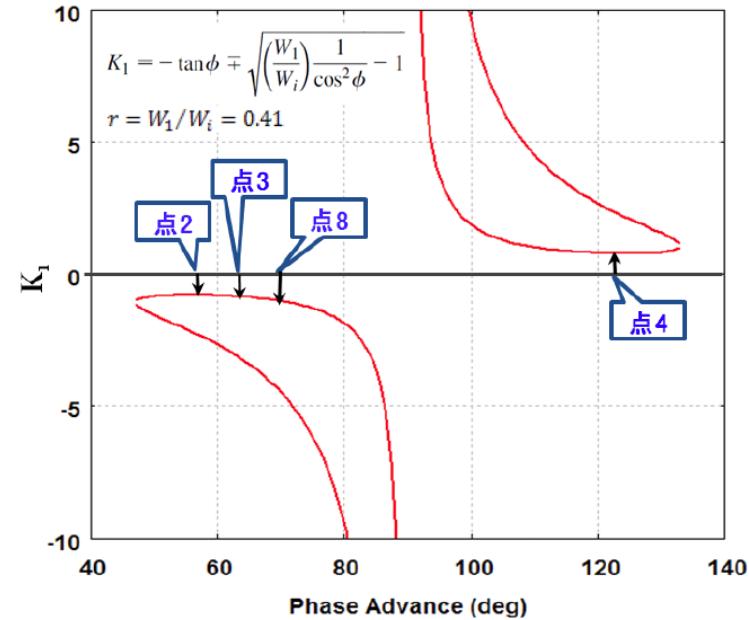
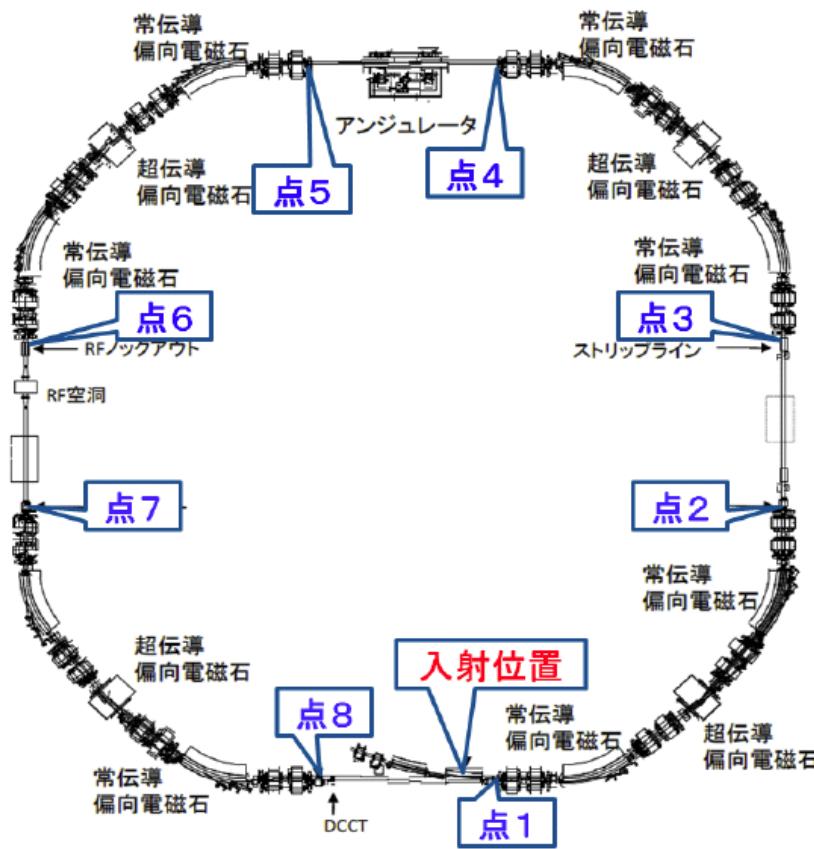
Horizontal Tune : 3.613
Vertical Tune : 3.261



PULSED MULTIPOLE FOR AICHI SR

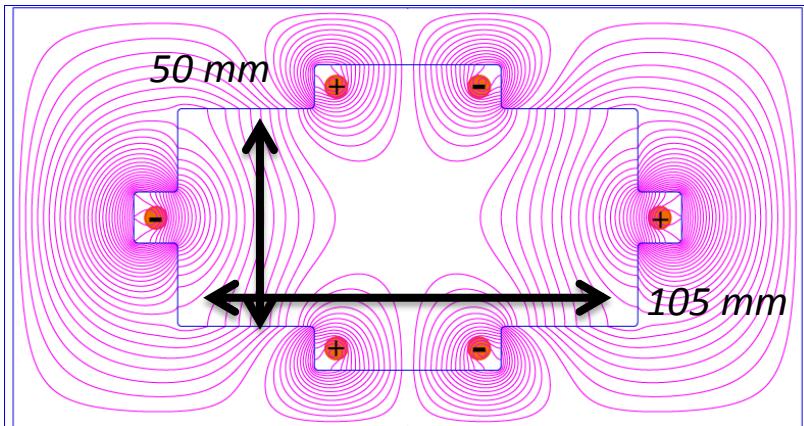
Multipole injection at Aichi SR (Machine condition)

Horizontal Tune : 4.724
Vertical Tune : 3.185

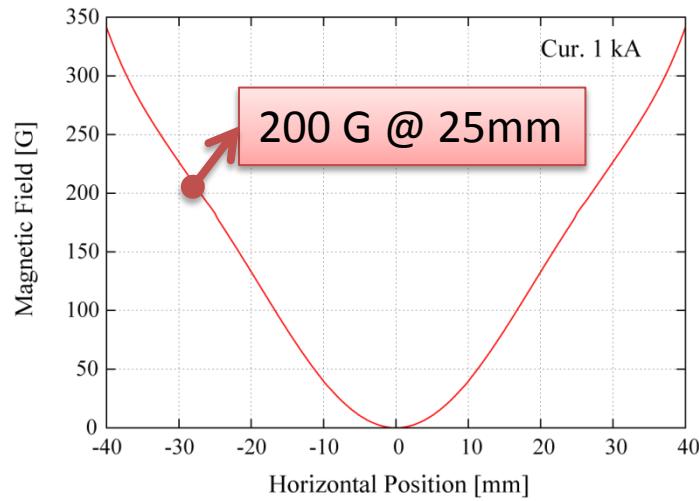


Multipole injection at Aichi SR (Magnet Design)

Design of Pulsed Magnet



Magnetic Field of Pulsed Magnet



Sextupole Magnet

Core Length : 200 mm

Vertical Gap : 50 mm

Horizontal Gap : 105 mm

Inductance : $1.8 \mu\text{H} (+ 1.8 \mu\text{H})$

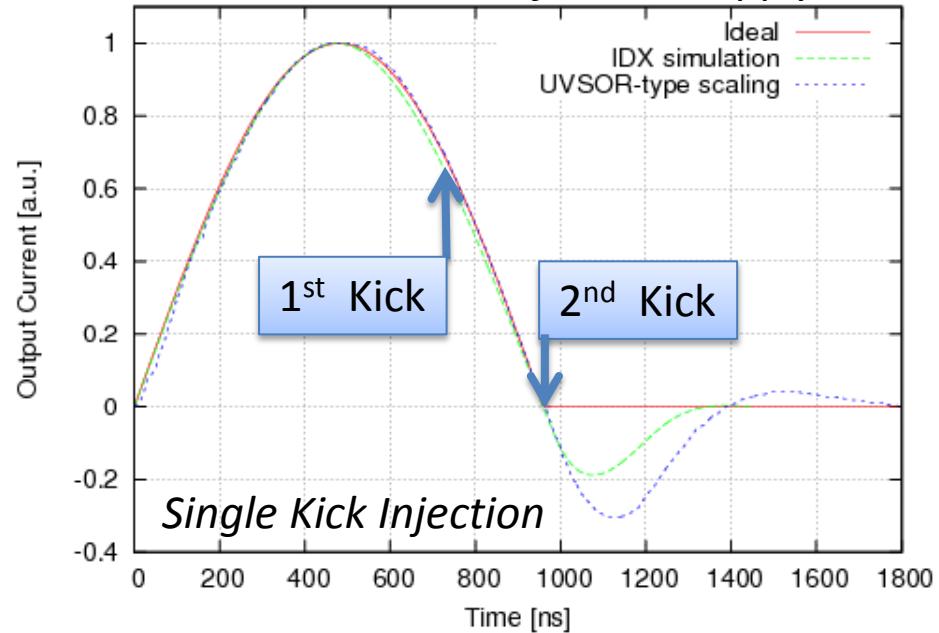
Power Supply

Max. Peak Current : **1400 A**

Max. Charging Voltage : **16 kV**

Pulse period : $0.96 \mu\text{s}$

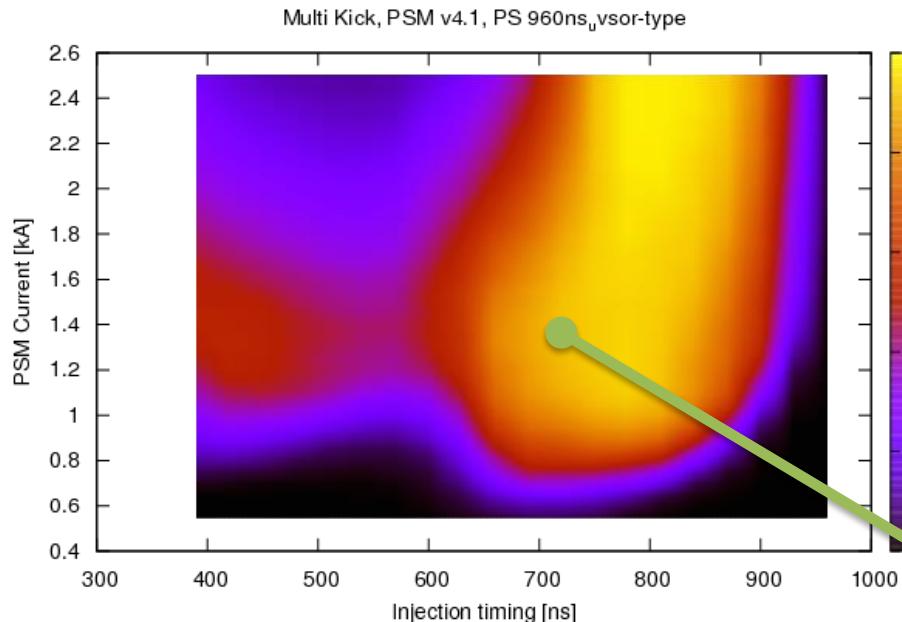
Pulse structure of Power supply



Multipole injection at Aichi SR (Calculation, Ideal case)

Betatron Tune : 4.724, 3.185

Chromaticity : 0 , 0

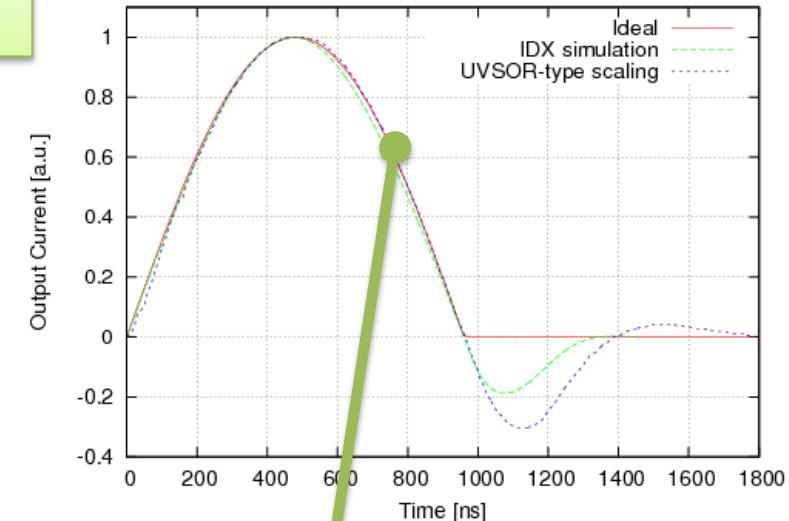


Power Supply

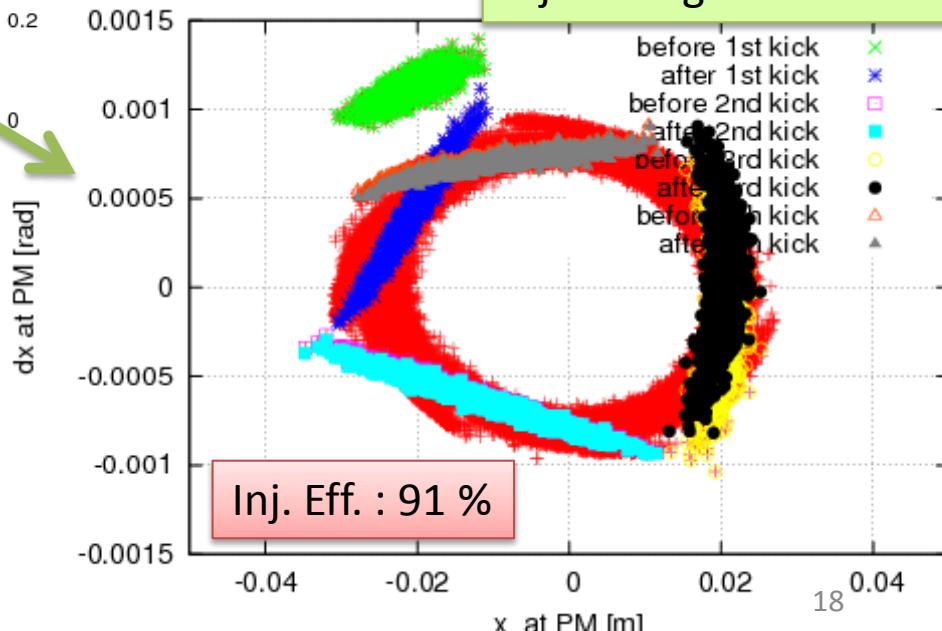
Max. Peak Current : 1400 A

Max. Charging Voltage : 16 kV

Pulse period : 0.96 μ s



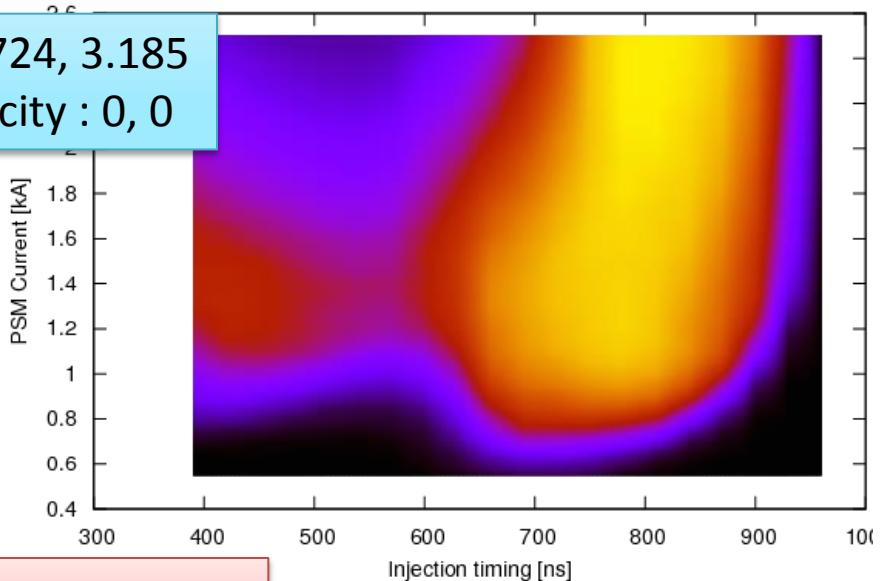
Max. Current : 1400 A
Inj. Timing : 720 ns



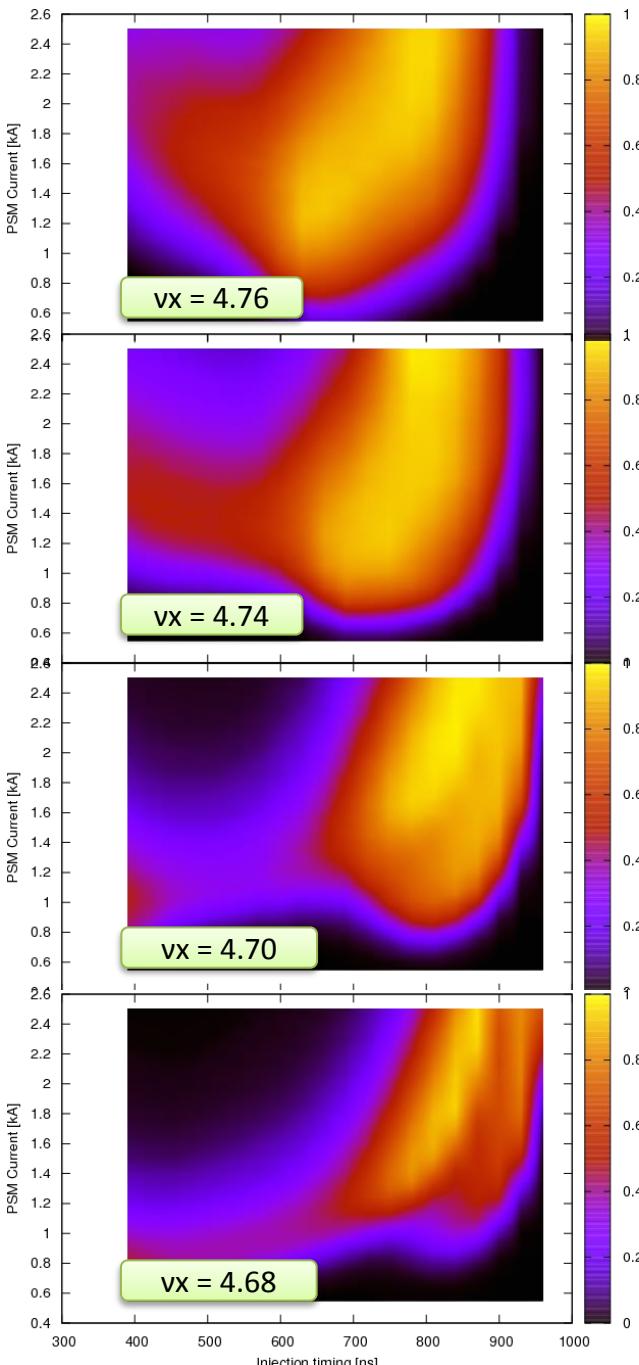
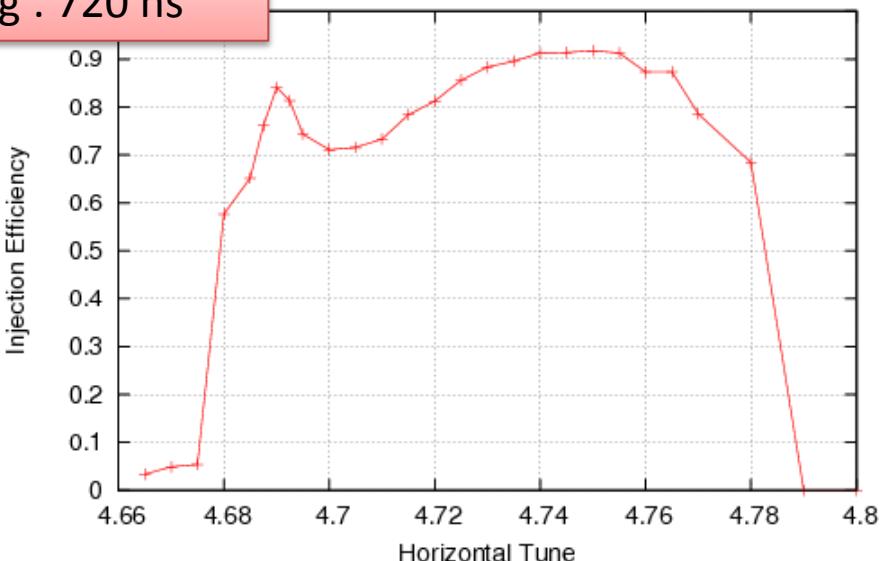
Multipole injection at Aichi SR (Calculation : Tune Dependence)

Tune : 4.724, 3.185

Chromaticity : 0, 0



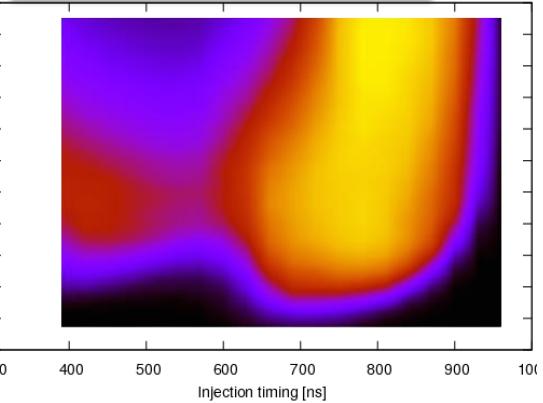
Max. Current : 1400 A
Inj. Timing : 720 ns



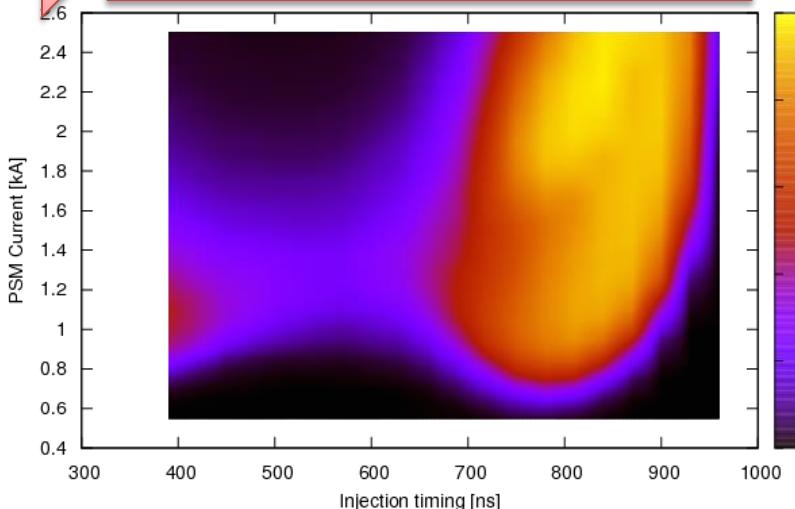
Multipole injection at Aichi SR

(Calculation : Chromaticity Dependence)

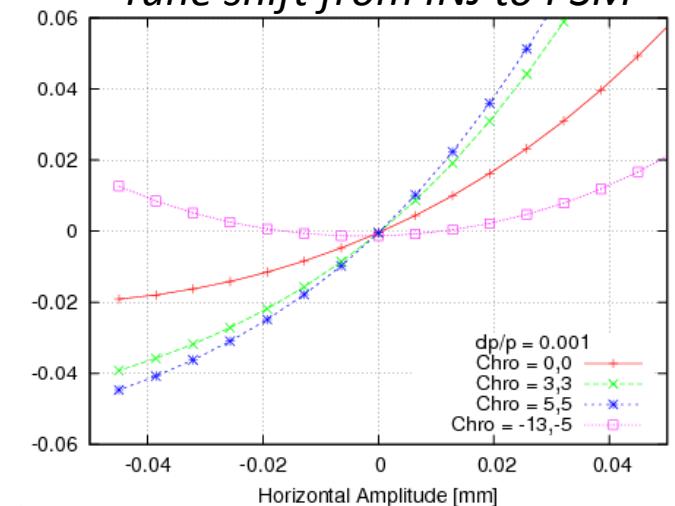
Chromaticity : 0, 0



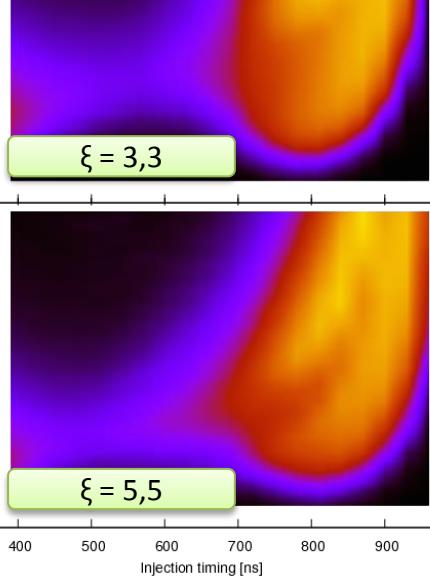
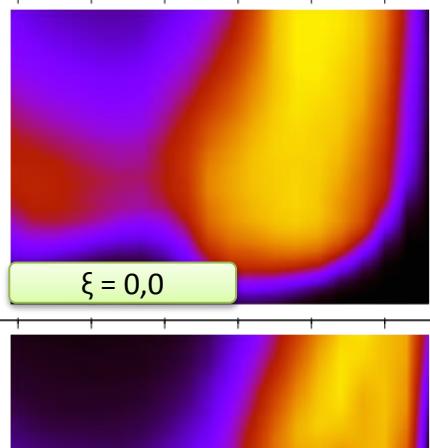
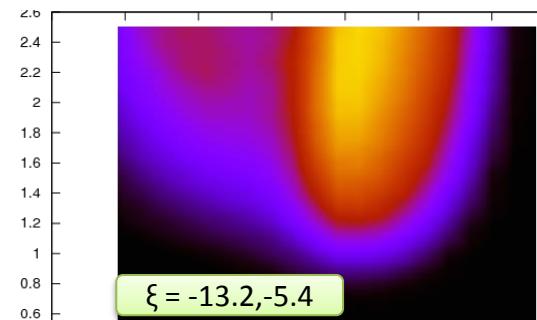
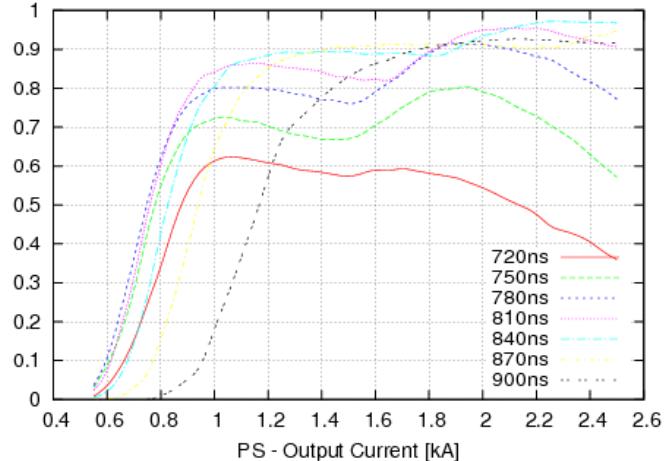
Betatron Tune : 4.724, 3.185
Chromaticity : 1.26, 5.66
* Operation point



Tune shift from INJ to PSM



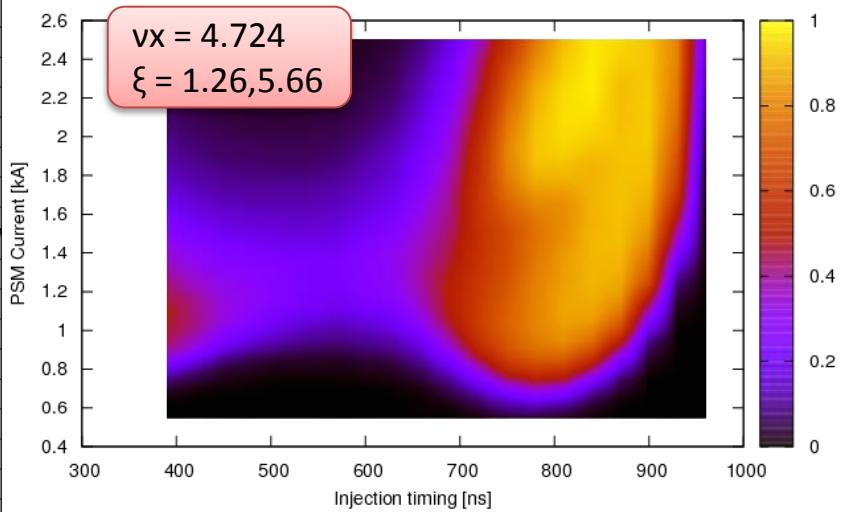
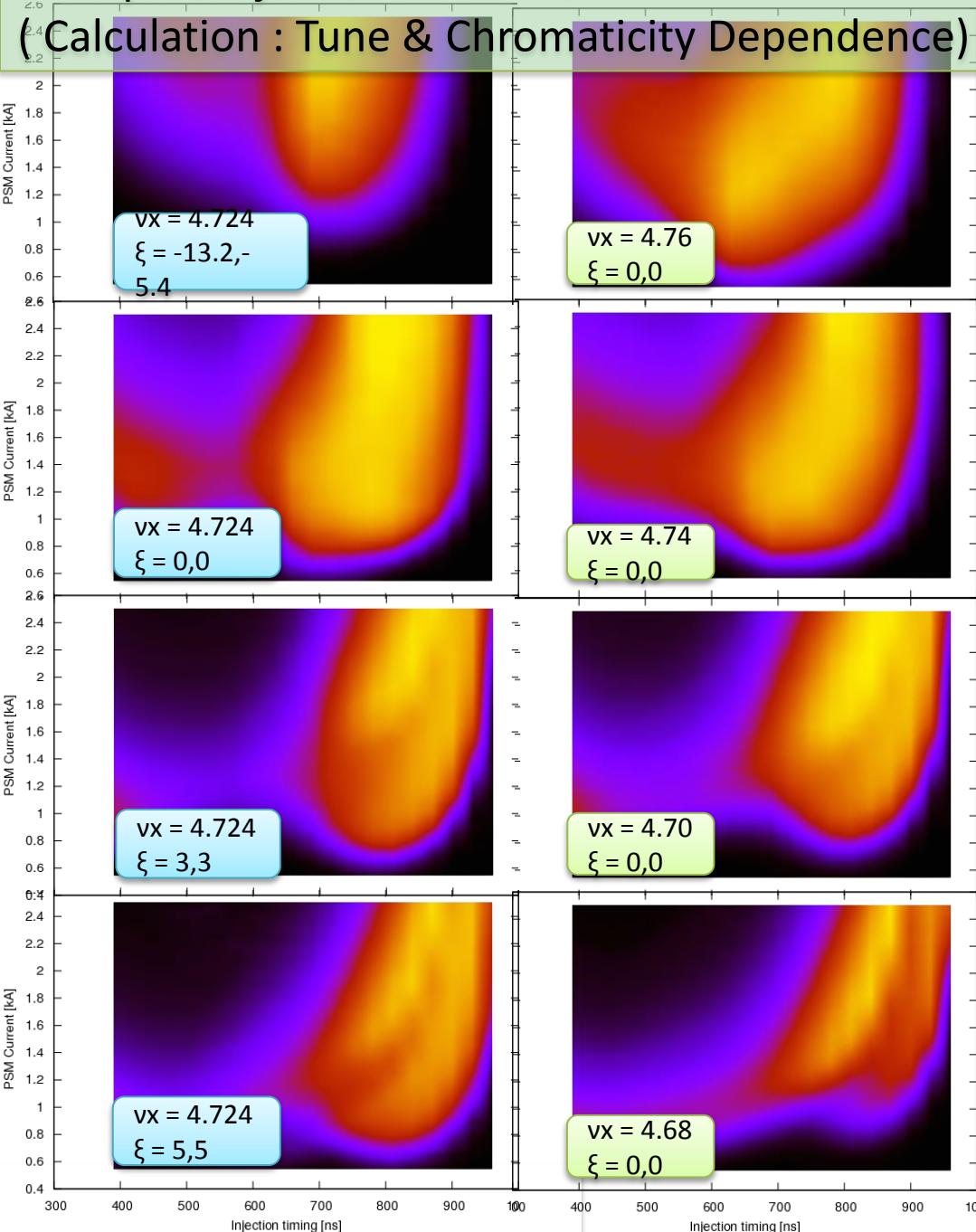
Inj. Eff. vs PS Current



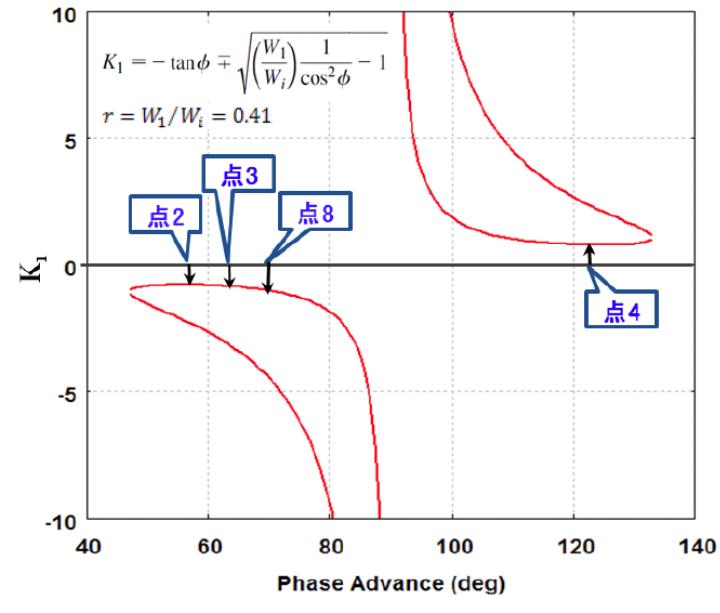
$\xi = 5,5$

Multipole injection at Aichi SR

(Calculation : Tune & Chromaticity Dependence)



Phase advance dependence

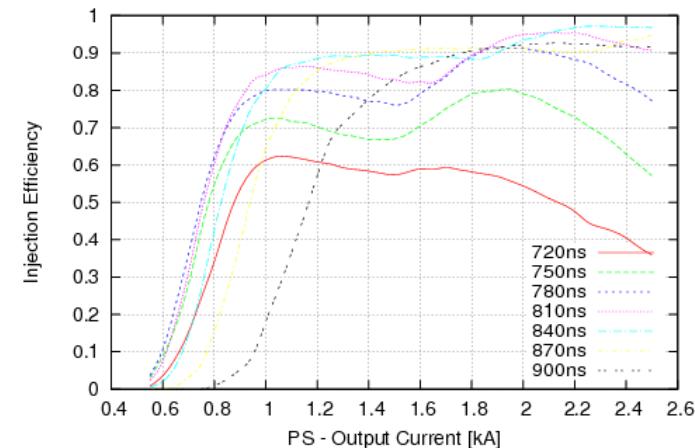


Multipole injection at Aichi SR (Calculation : Decision of Power Supply Specs)

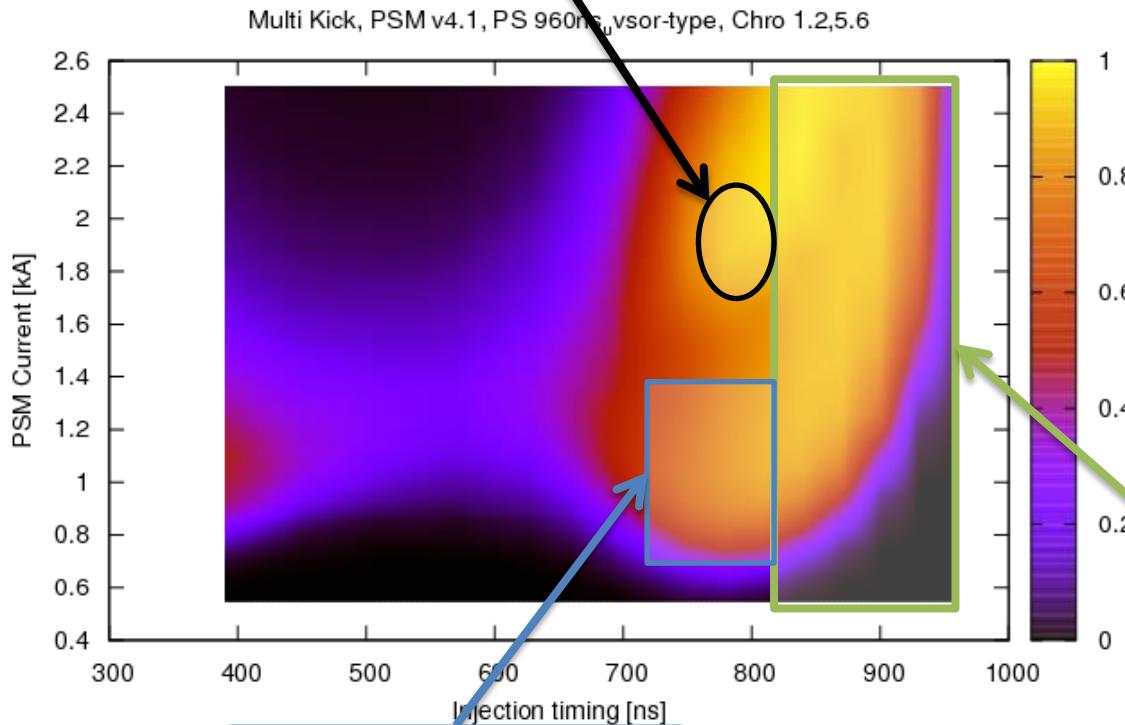
Betatron Tune : 4.724, 3.185

Chromaticity : 1.26, 5.66

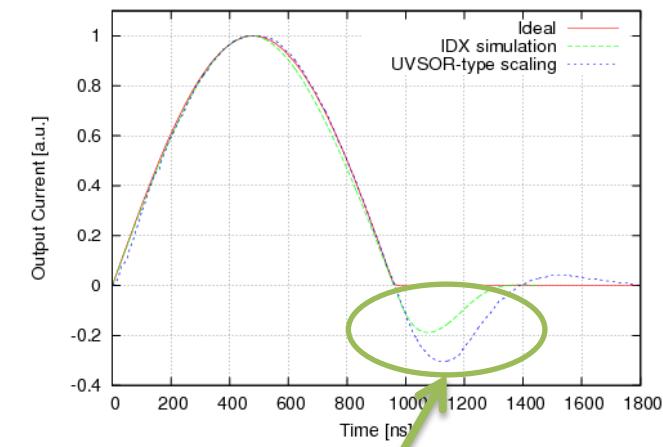
* Operation point



Should we choose this region ?

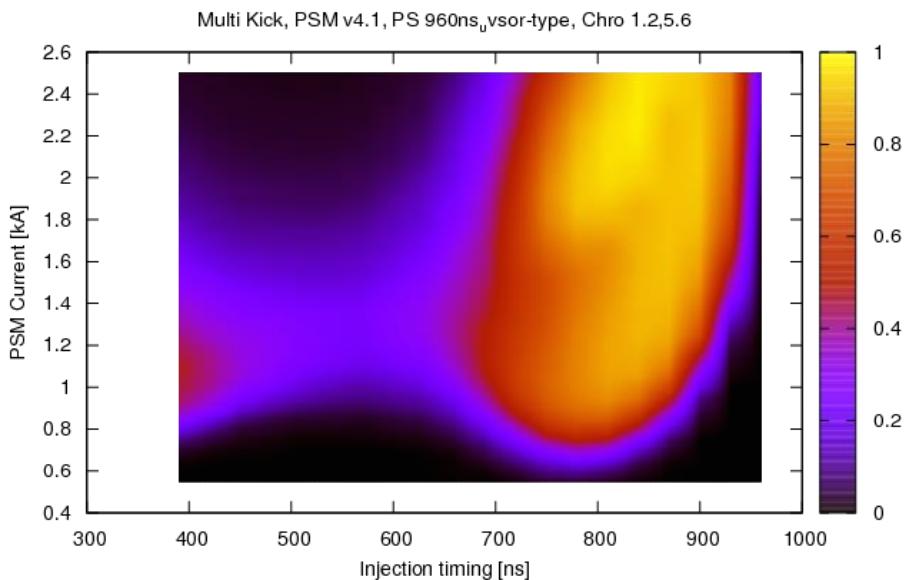
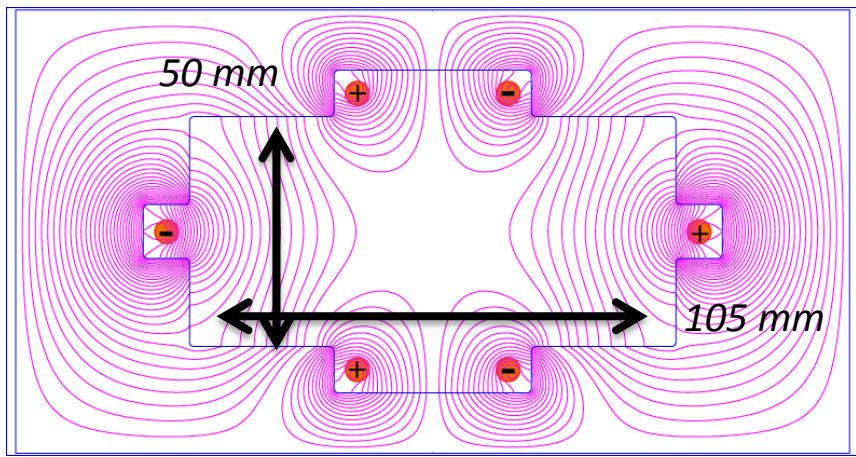


Chromaticity depend



Inv. Current depend

Multipole injection at Aichi SR (Summary)



Sextupole Magnet

Core Length : 200 mm

Vertical Gap : 50 mm

Horizontal Gap : 105 mm

Inductance : 1.8 μ H (+ 1.8 μ H)

Power Supply

Max. Peak Current : **2000 A**

Max. Charging Voltage : **23 kV**

Pulse period : 0.96 μ s



At operation point,

Betatron Tune : 4.724, 3.185

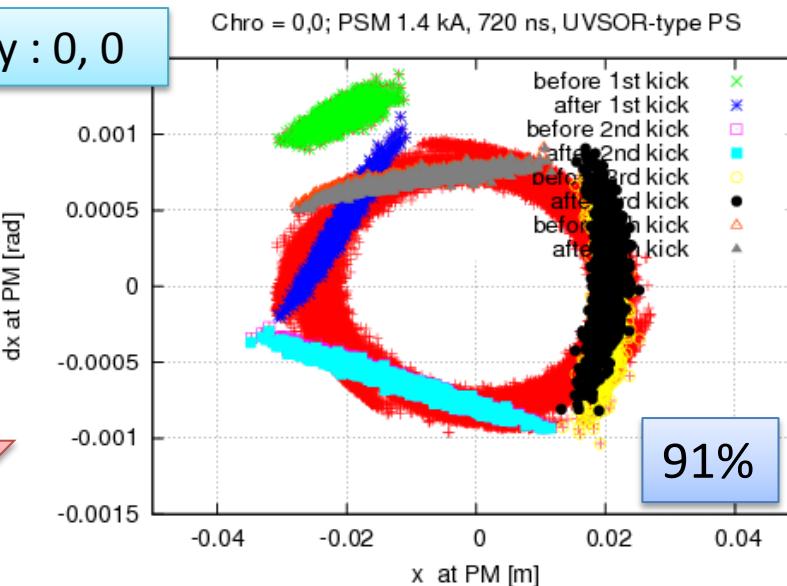
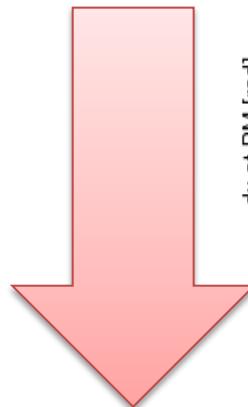
Chromaticity : 1.26, 5.66

Is Inj. Eff. of 80 ~ 90 % achieved ?

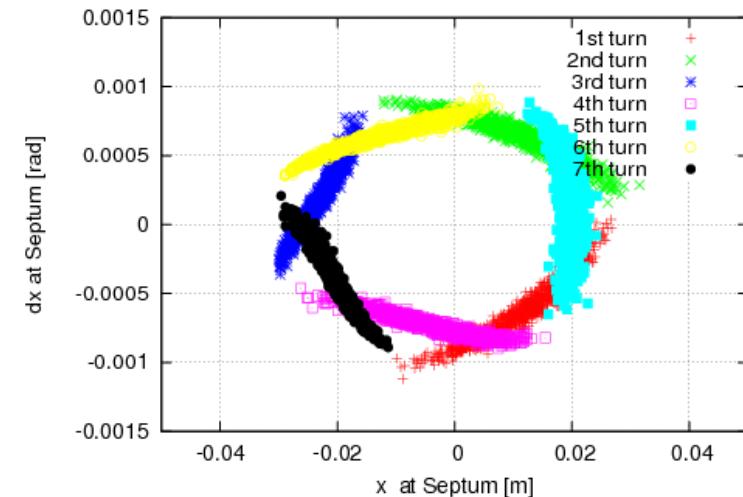
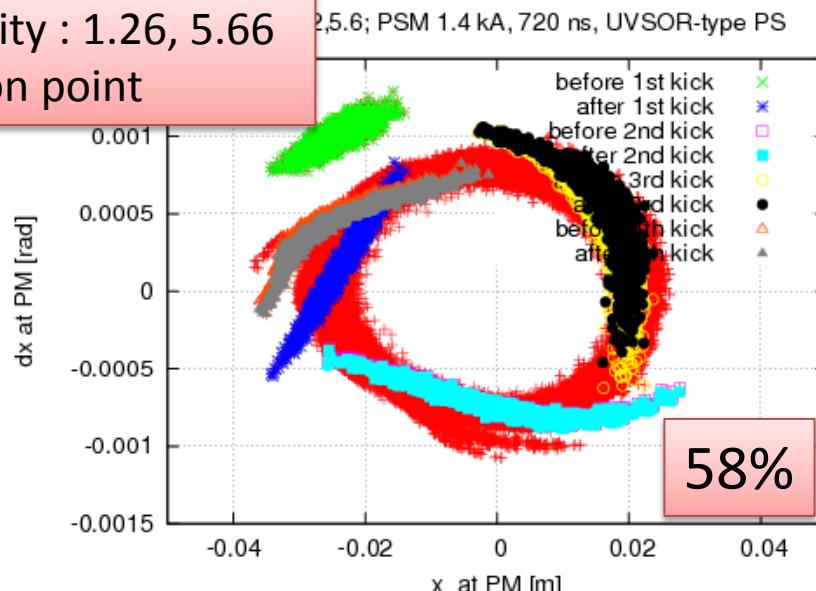
THANK YOU FOR YOUR ATTENTION

(Calculation : Chromaticity Dependence)

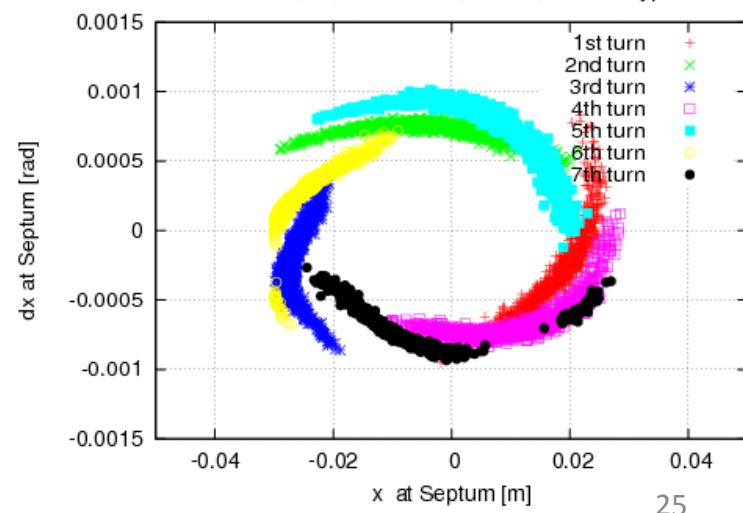
Chromaticity : 0, 0



Chro = 0,0; PSM 1.4 kA, 720 ns, UVSOR-type PS

Chromaticity : 1.26, 5.66
* Operation point

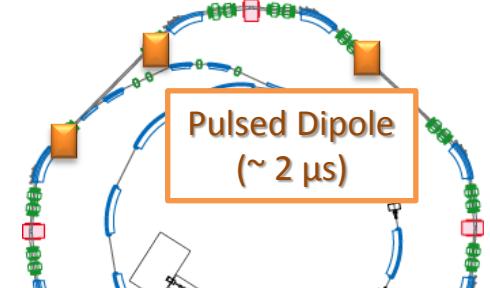
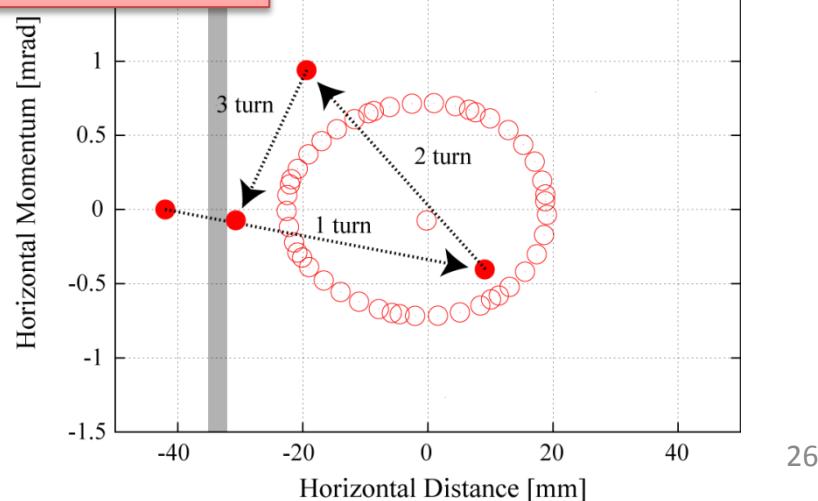
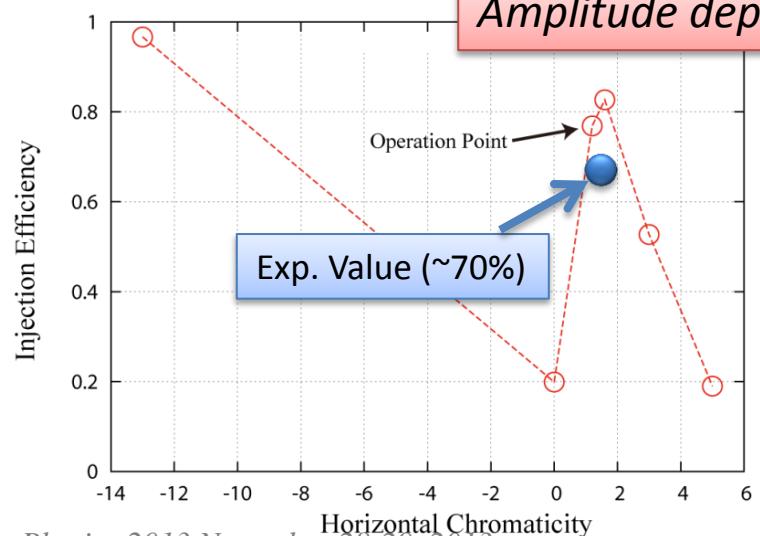
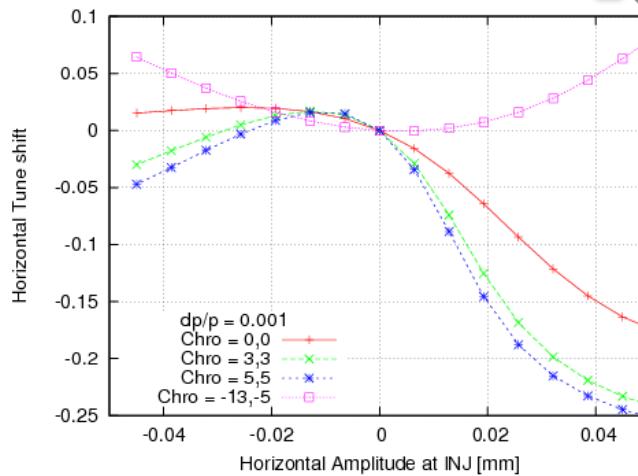
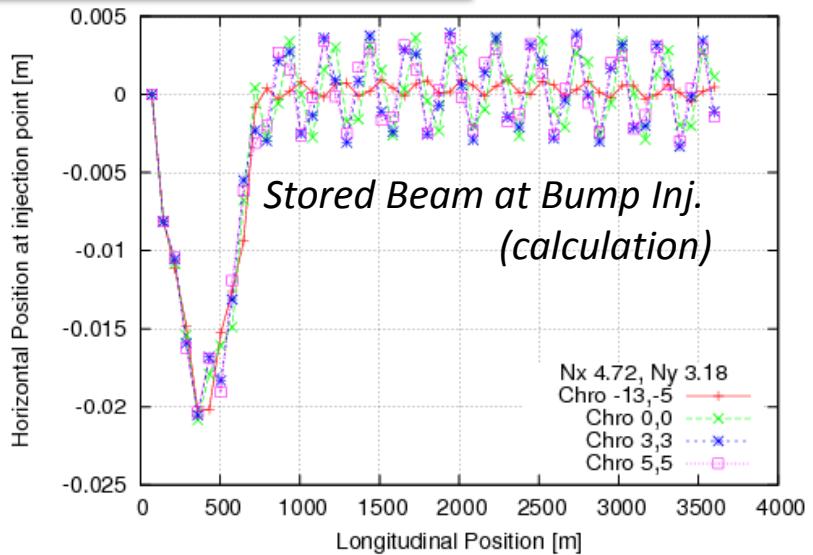
Chro = 1.2,5.6; PSM 1.4 kA, 720 ns, UVSOR-type PS



(for comparison). Bump injection at Aichi SR

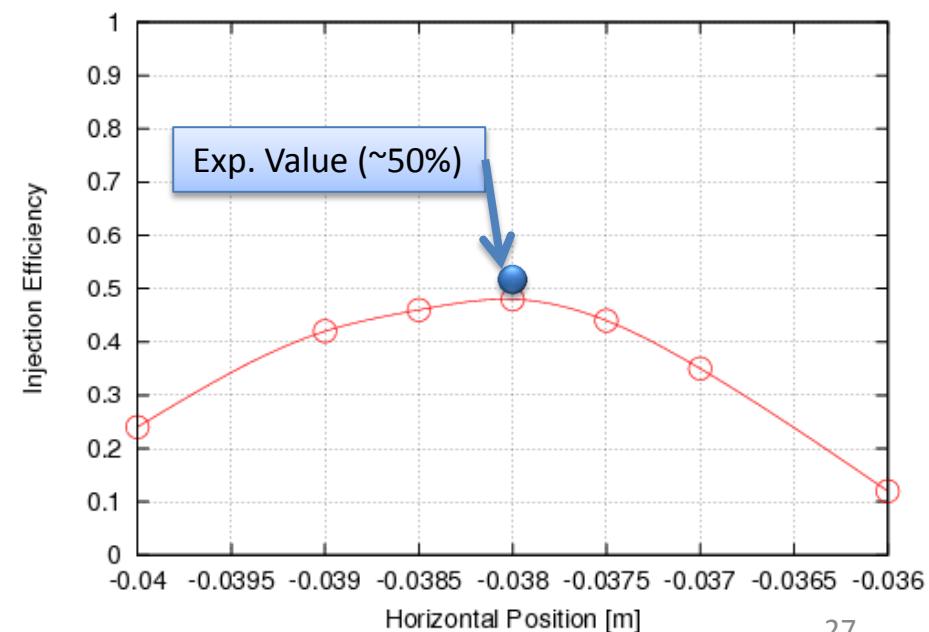
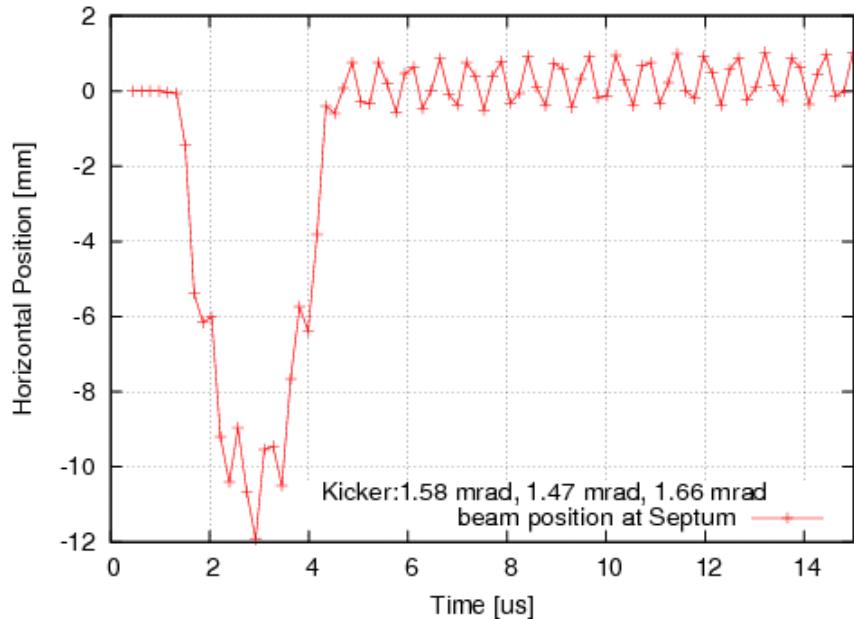
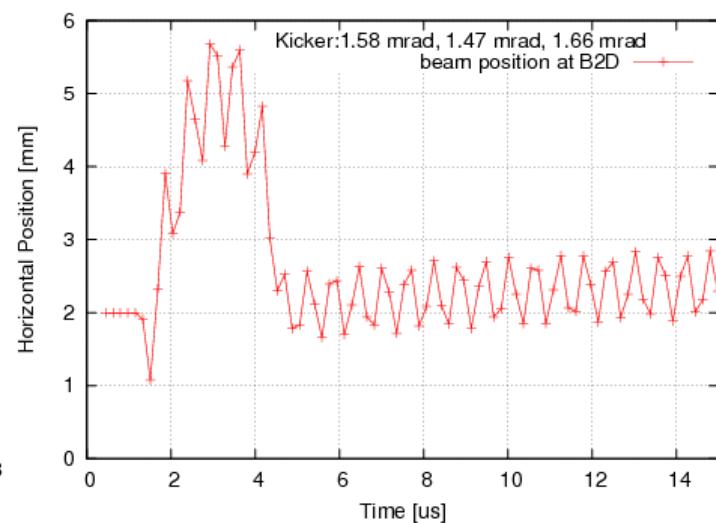
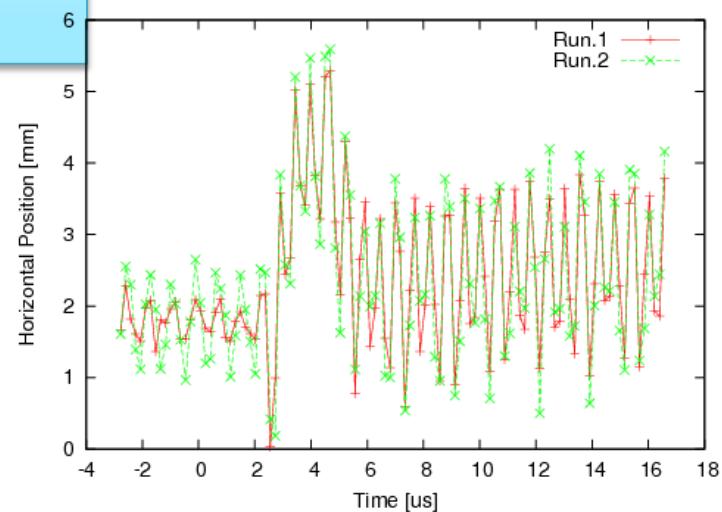
Horizontal Tune : 4.724

Vertical Tune : 3.185



(for comparison). Bump injection at UVSOR

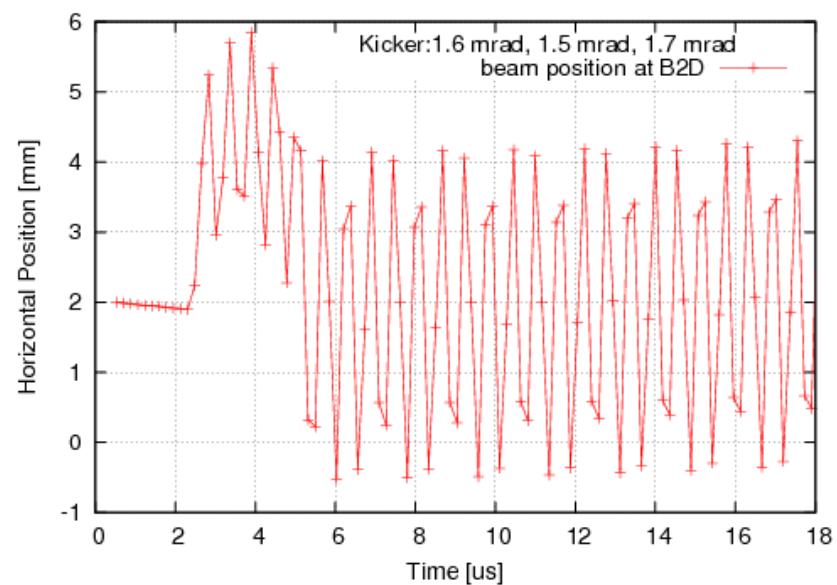
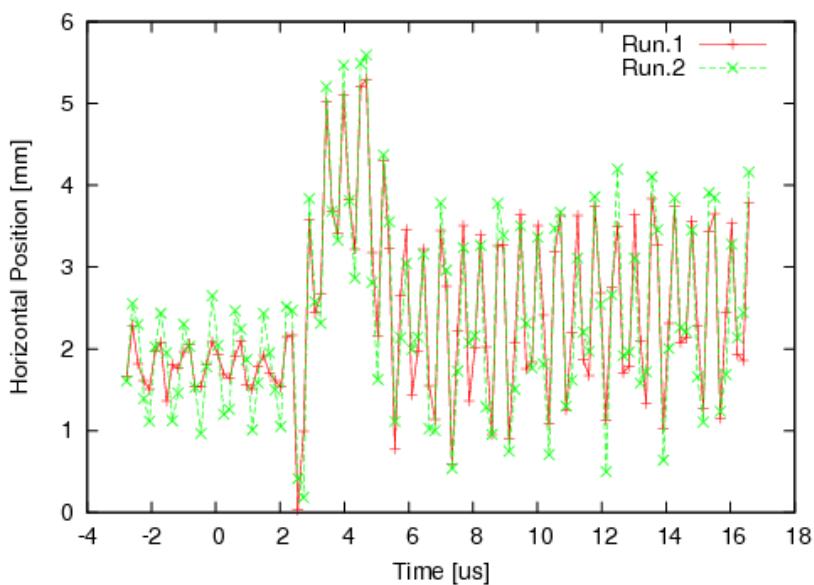
Horizontal Tune : 3.70
Vertical Tune : 3.20



入射軌道の測定 (B2D)

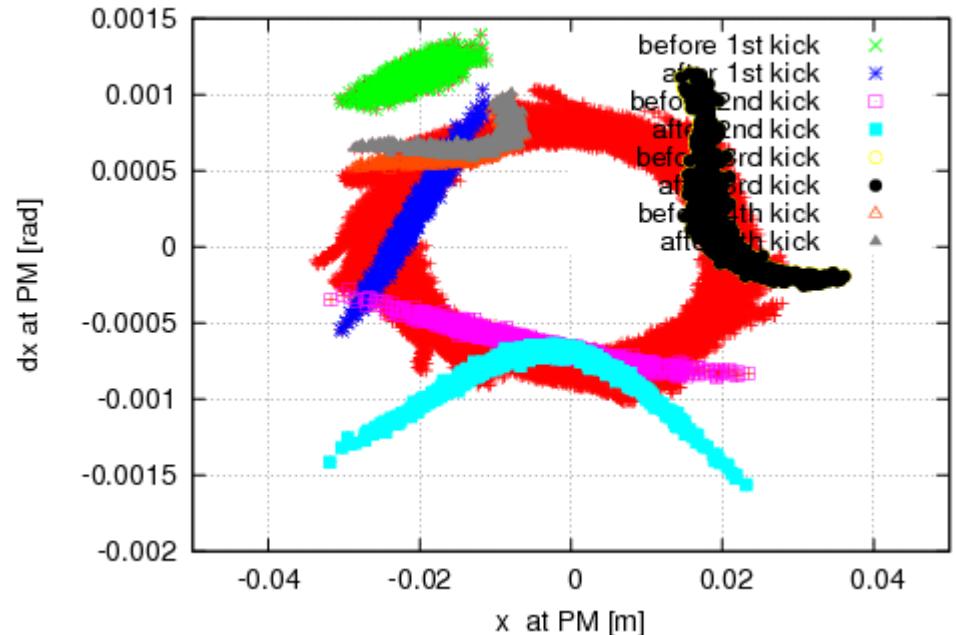
実測のBPMデータ

SADでの再現

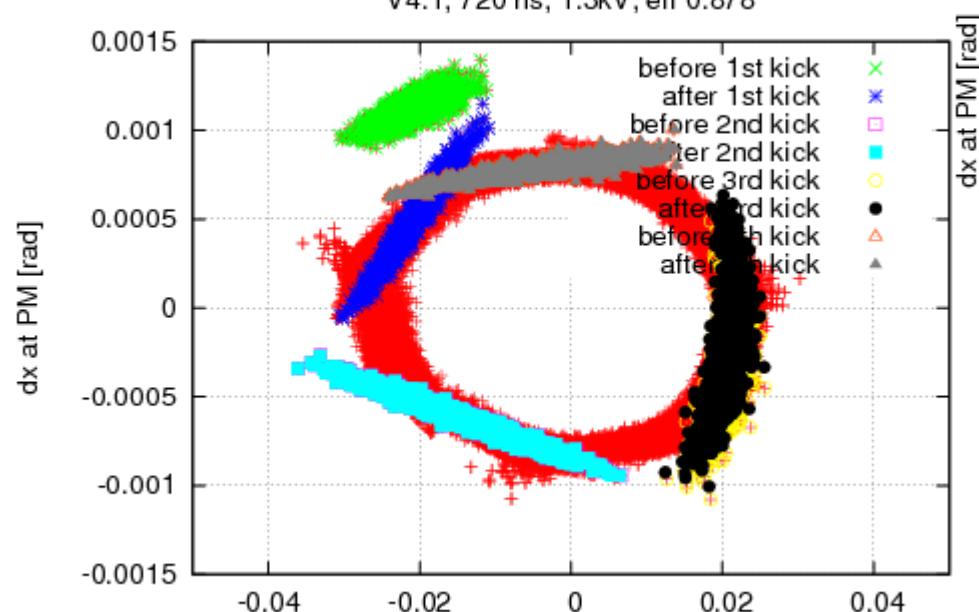


理想波形でのMulti Kick

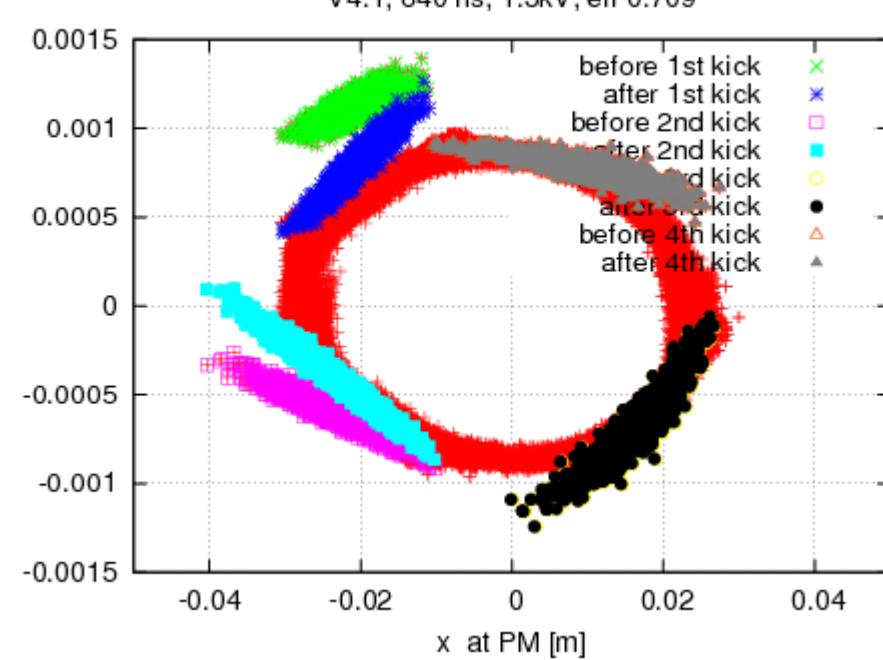
V4.1, 480 ns, 1.3kV, eff 0.615



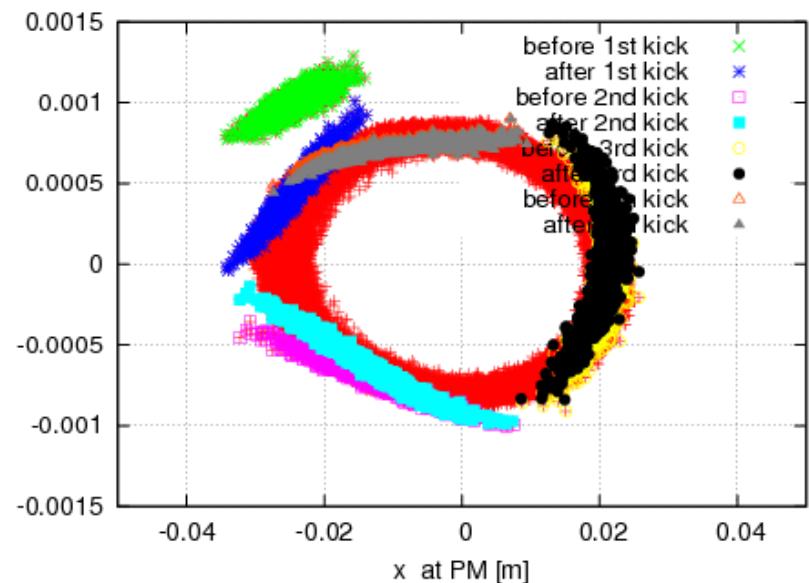
V4.1, 720 ns, 1.3kV, eff 0.878



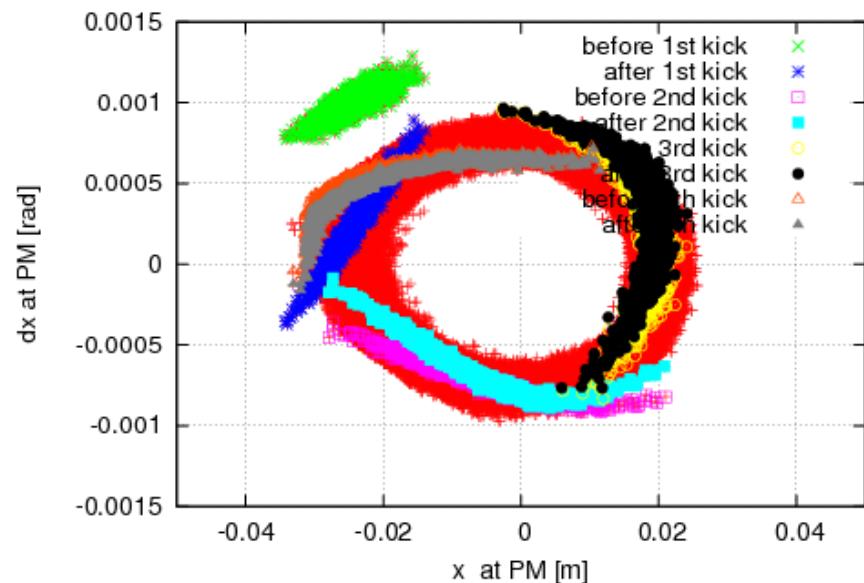
V4.1, 840 ns, 1.3kV, eff 0.709



Chro = 1.2,5,6; PSM 1.1 kA, 780 ns, UVSOR-type PS, Eff 0.802



Chro = 1.2,5,6; PSM 1.55 kA, 780 ns, UVSOR-type PS, Eff 0.770



Chro = 1.2,5,6; PSM 1.9 kA, 780 ns, UVSOR-type PS, Eff 0.913

