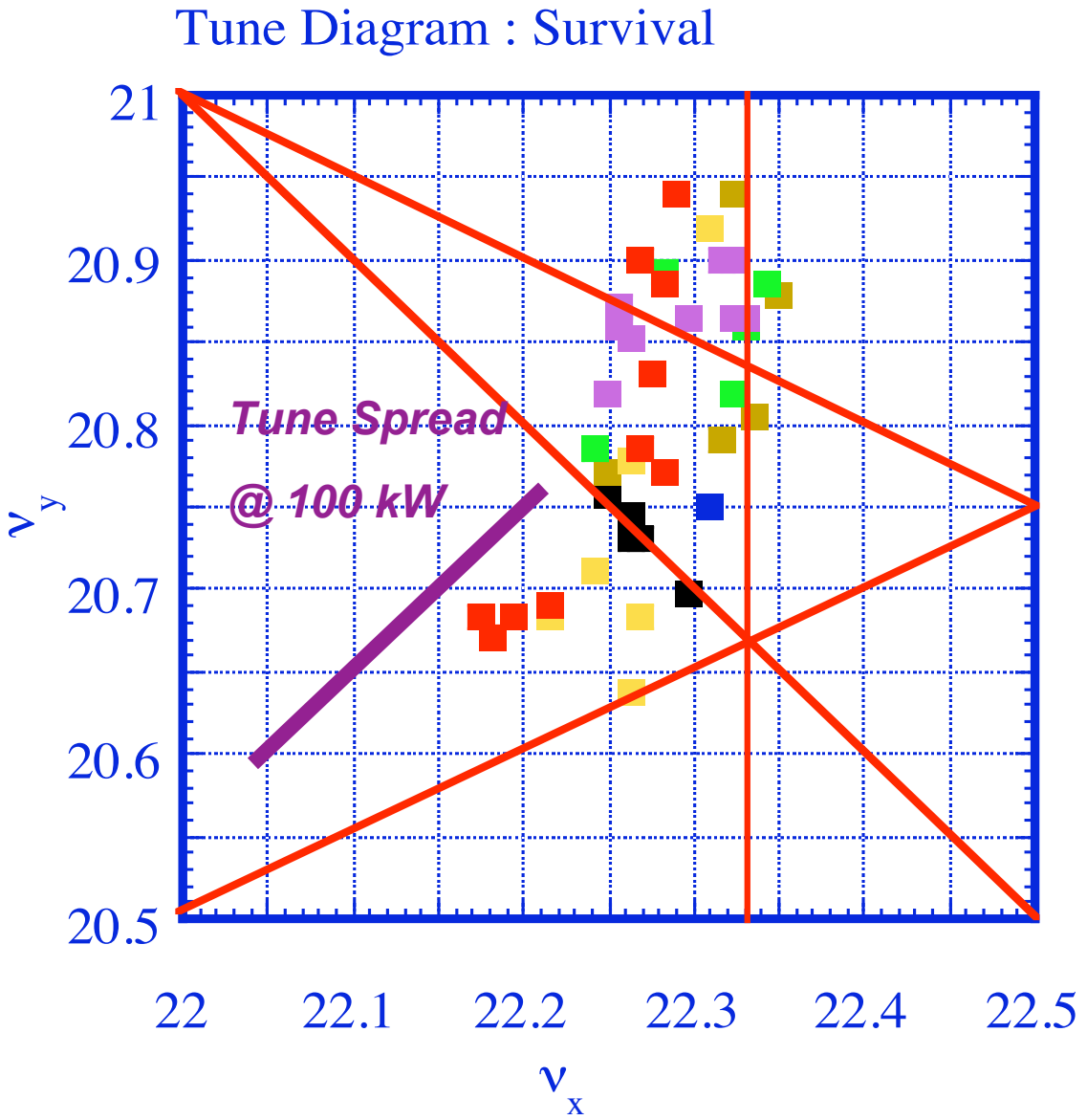
MR Status & Commissioning Plan

J-PARC PAC 2008. 10. 16 A. Ando

1. Main Results of 3 Gave DC Operation @ May ~ June, 2008
   1) Tune Diagram Survey
   2) Ripples in Power Supplies of Main Magnets
2. Main Improvement in this Summer & Autumn
   - Attainment & Limits
3. Commissioning Plan for 30 Gave Acceleration and Extraction to Hadrons Beam Line
   - Goal : Guide Protons to Hadron Dump
4. Perspectives for Run from April, 2009
   1) Stable Operation @ 100 kW
   2) How to Reach to the level of 300 kW and More

Tune Survey



Beam Survival
@ 0.83 sec
after Injection :
~ n × 10 %

1 sec Storage

Tune Ripple : $\Delta\nu$ = ~ ± 0.03

<=== QM ripple : ~ 10^{-4}

100 kW : Probably OK

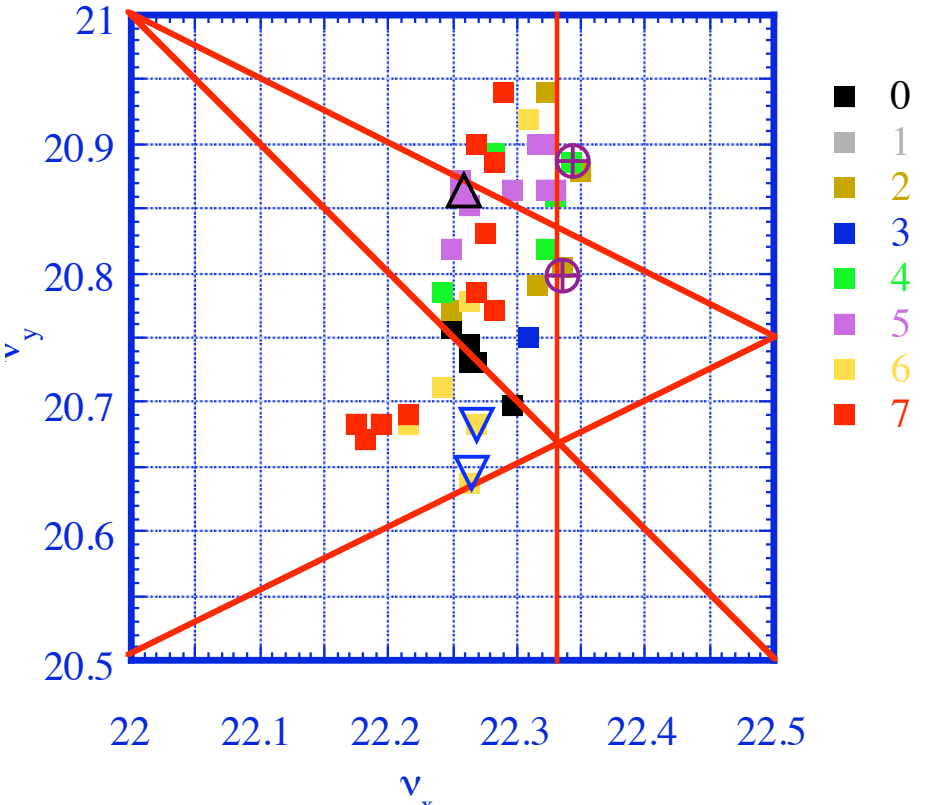
300 kW : Need Correction of
$\nu_x + \nu_y = 43$ Resonance &
$\Delta\nu < 10^{-4}$

0.016 ~ 0.017 / 6 bunches & 0.3 Hz Operation

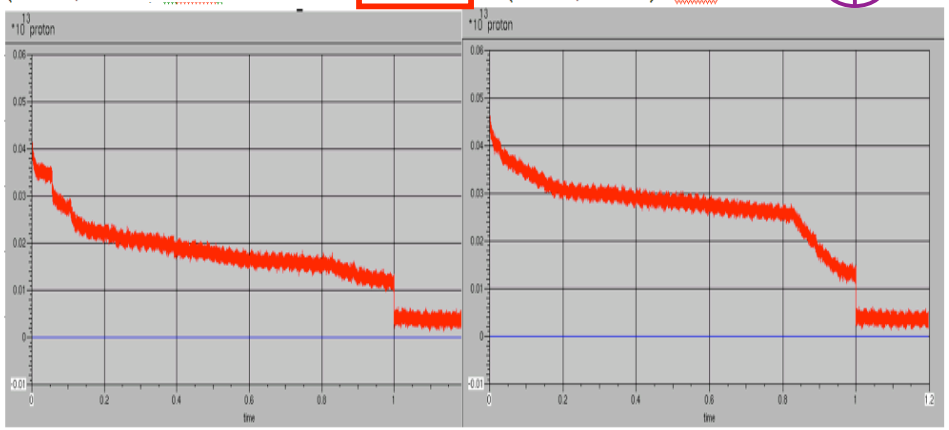
Resonances

$\Delta\nu$: ~ ± 0.03

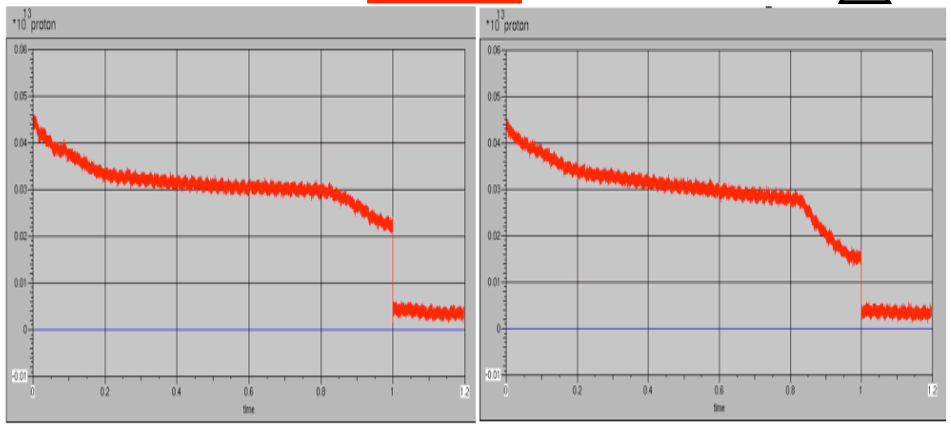
Tune Diagram : Survival



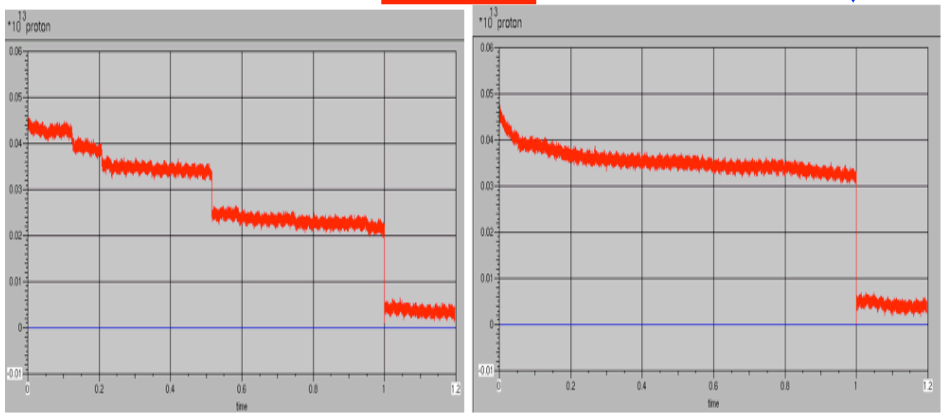
(22.337, **20.805** / Sext. ON ==> $3\nu_x = 67$ ---> (22.343, 20.886) / Sext. OFF



(22.256, 20.859) / Sext. ON <====> $\nu_x + 2\nu_y = 64$ (22.256, 20.872) / Sext. OFF

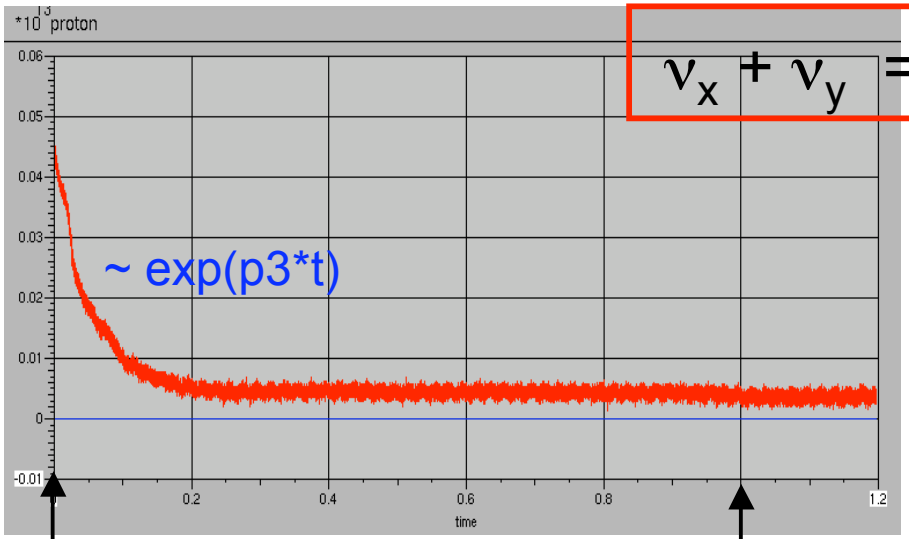


(22.269, 20.684)) / Sext. ON <====> $\nu_x - 2\nu_y = -19$ (22.263, 20.637) / Sext. OFF

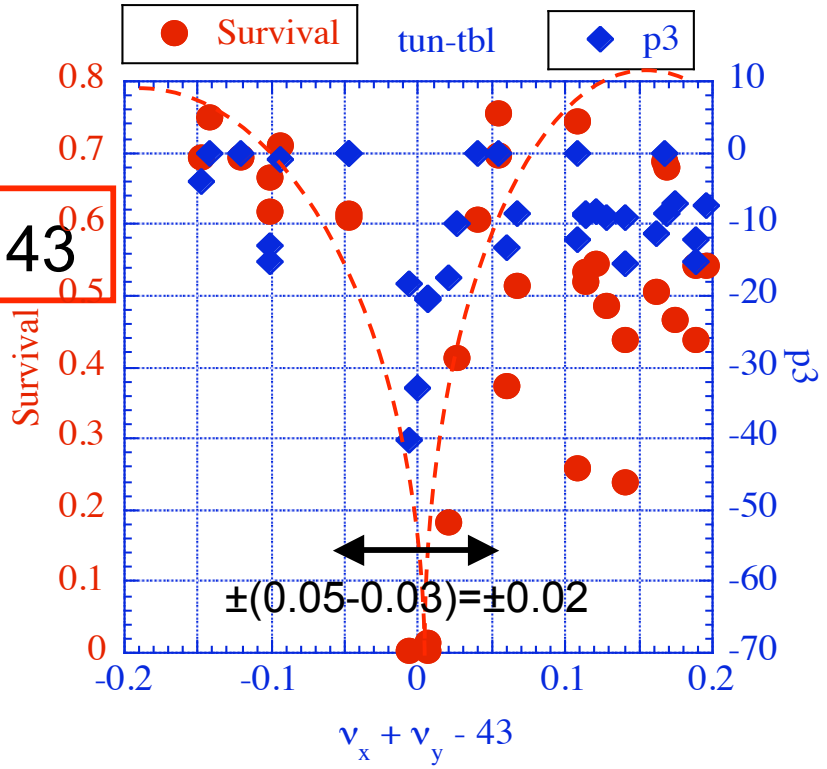


Resonance

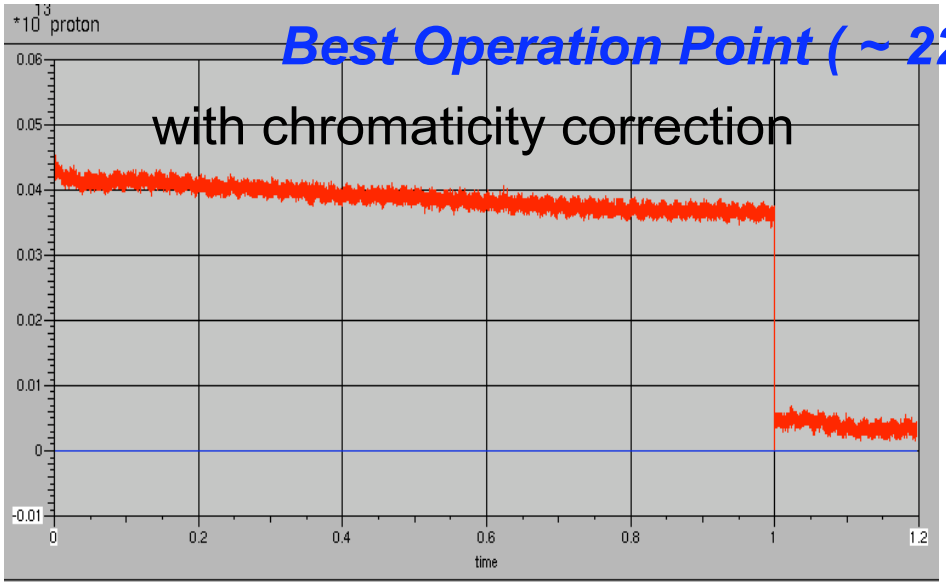
$\Delta\nu$: ~ ± 0.03

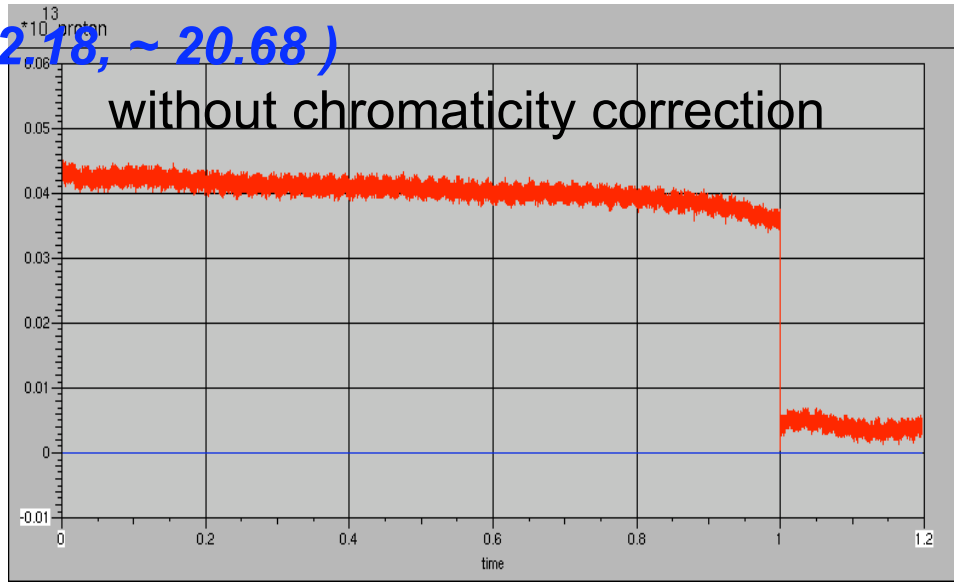


$\nu_x + \nu_y = 43$

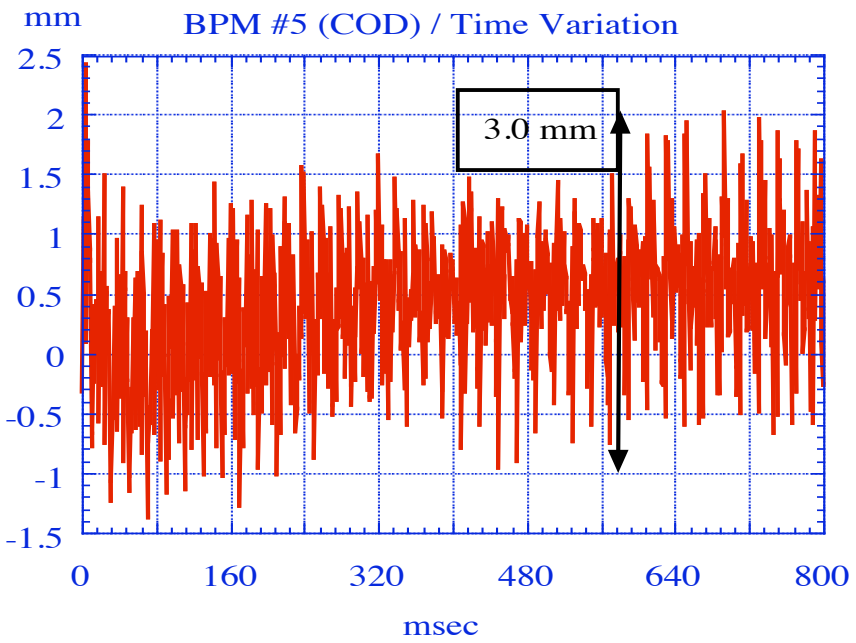


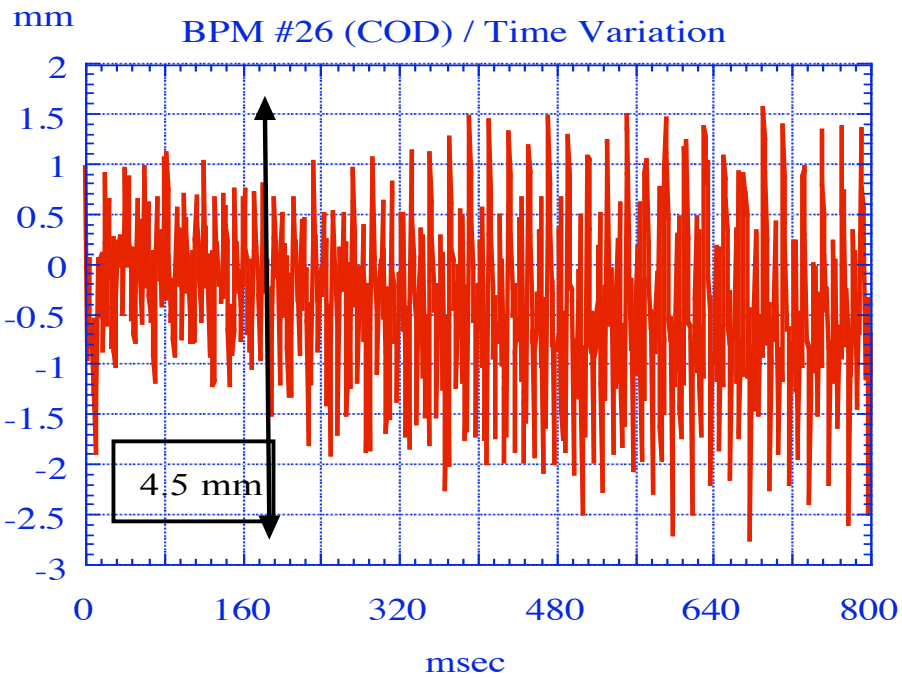
Best Operation Point (~ 22.18, ~ 20.68)

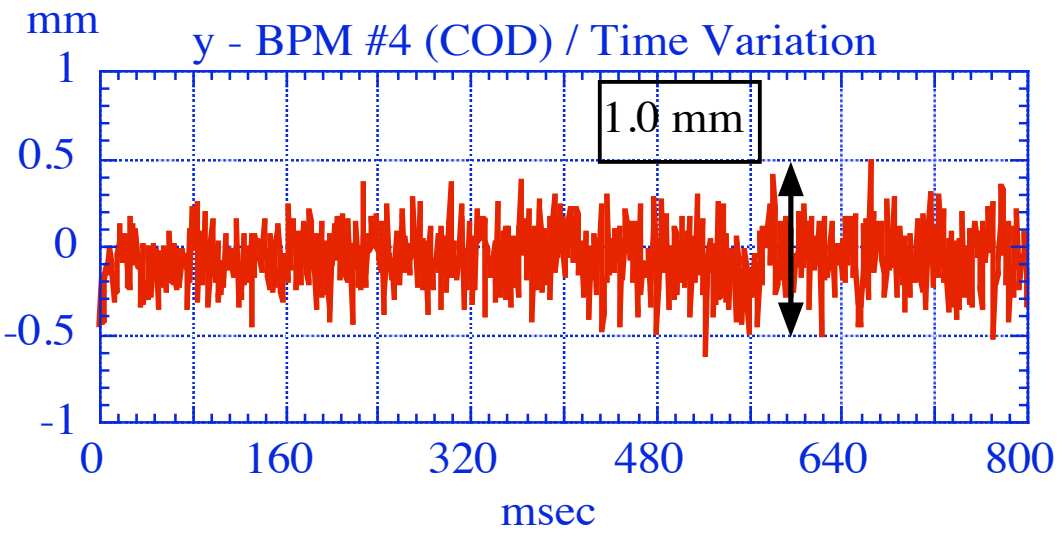




Ripple / Oscillation of Horizontal COD







Vertical

Ripple / Oscillation of Horizontal COD

Source : Current Ripples of Power Supply for BM

Ripples

(Almost) Any Frequency at 50*n Hz

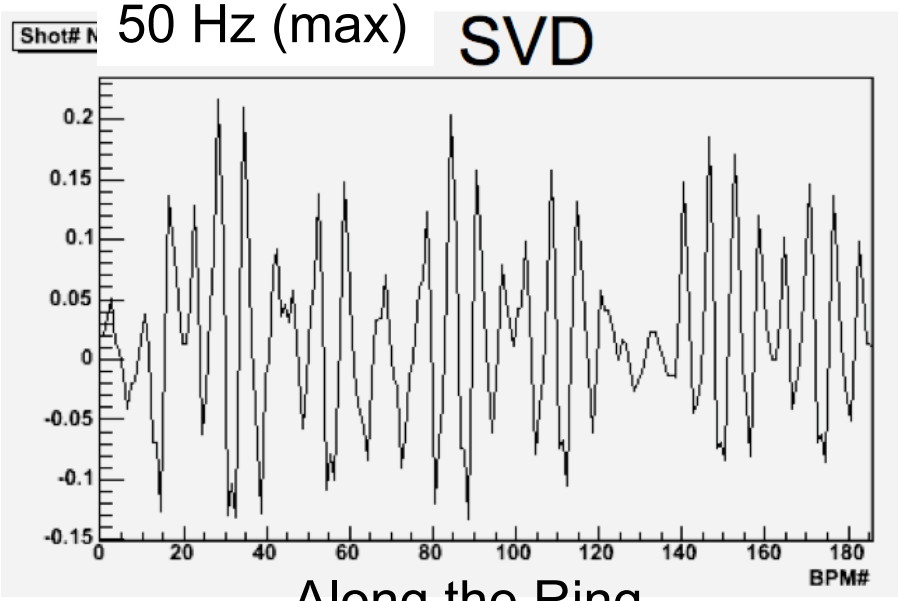
Any Pattern along the Ring

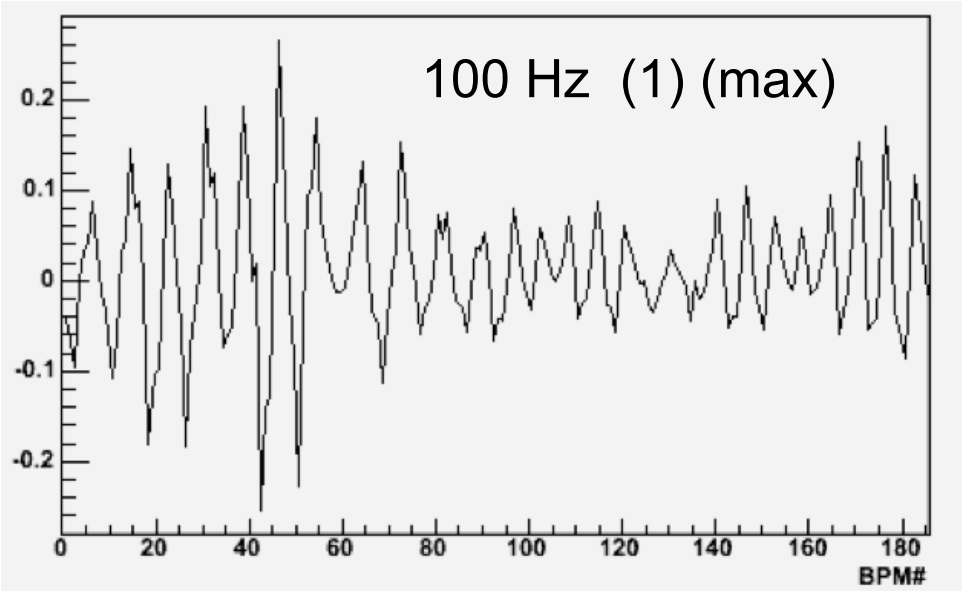
not Uniform in 96 Bending Magnets

Changing Magnitude in Time

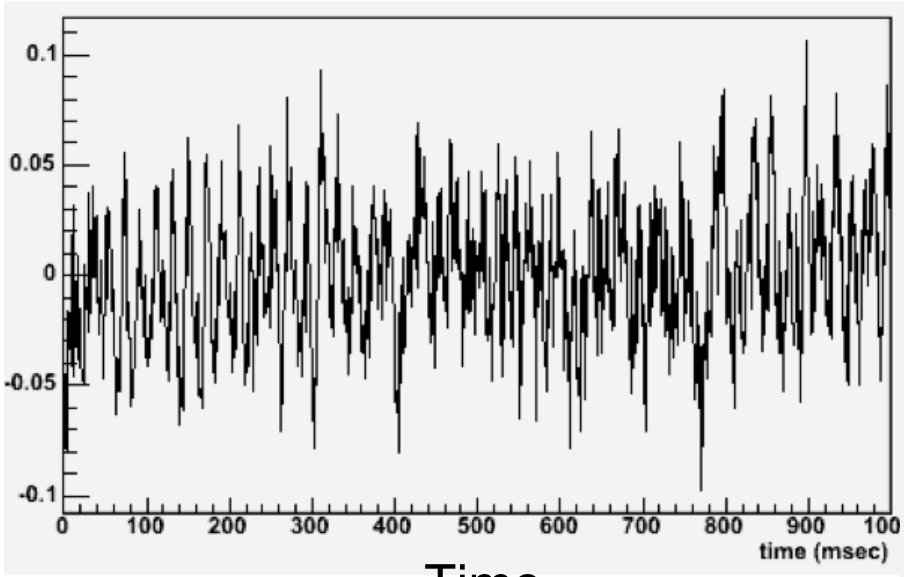
Some Examples

50 & 100 Hz Components

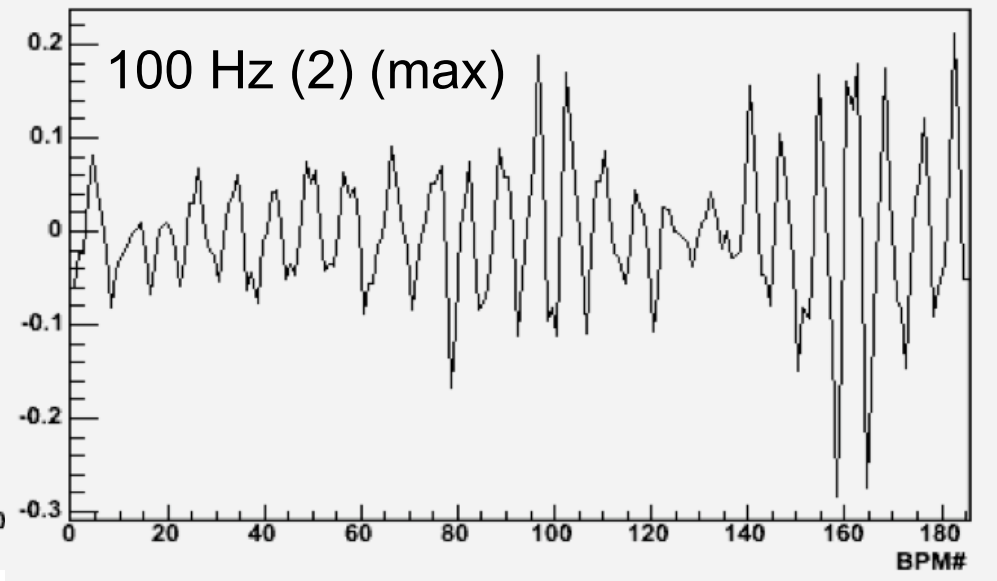


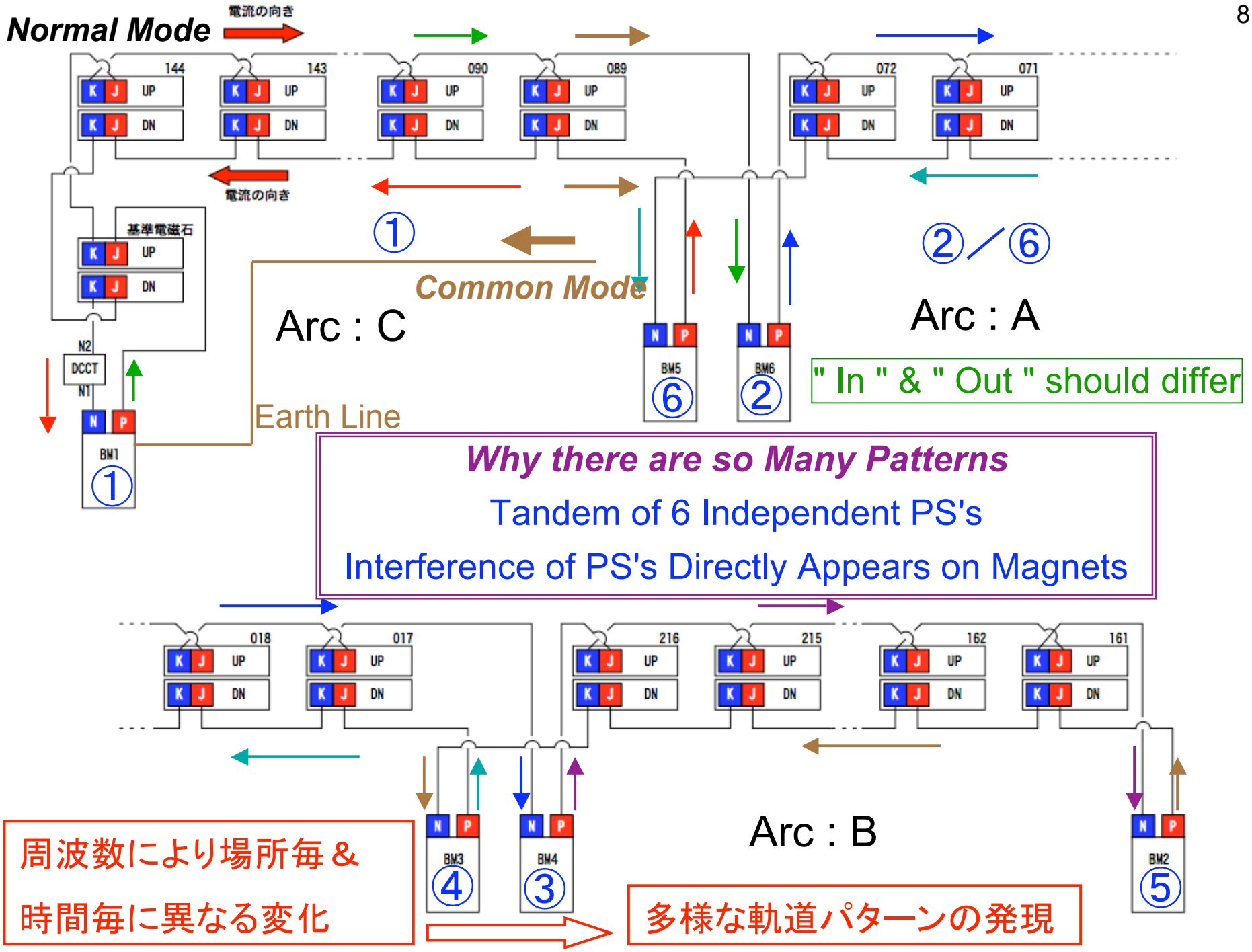


Along the Ring



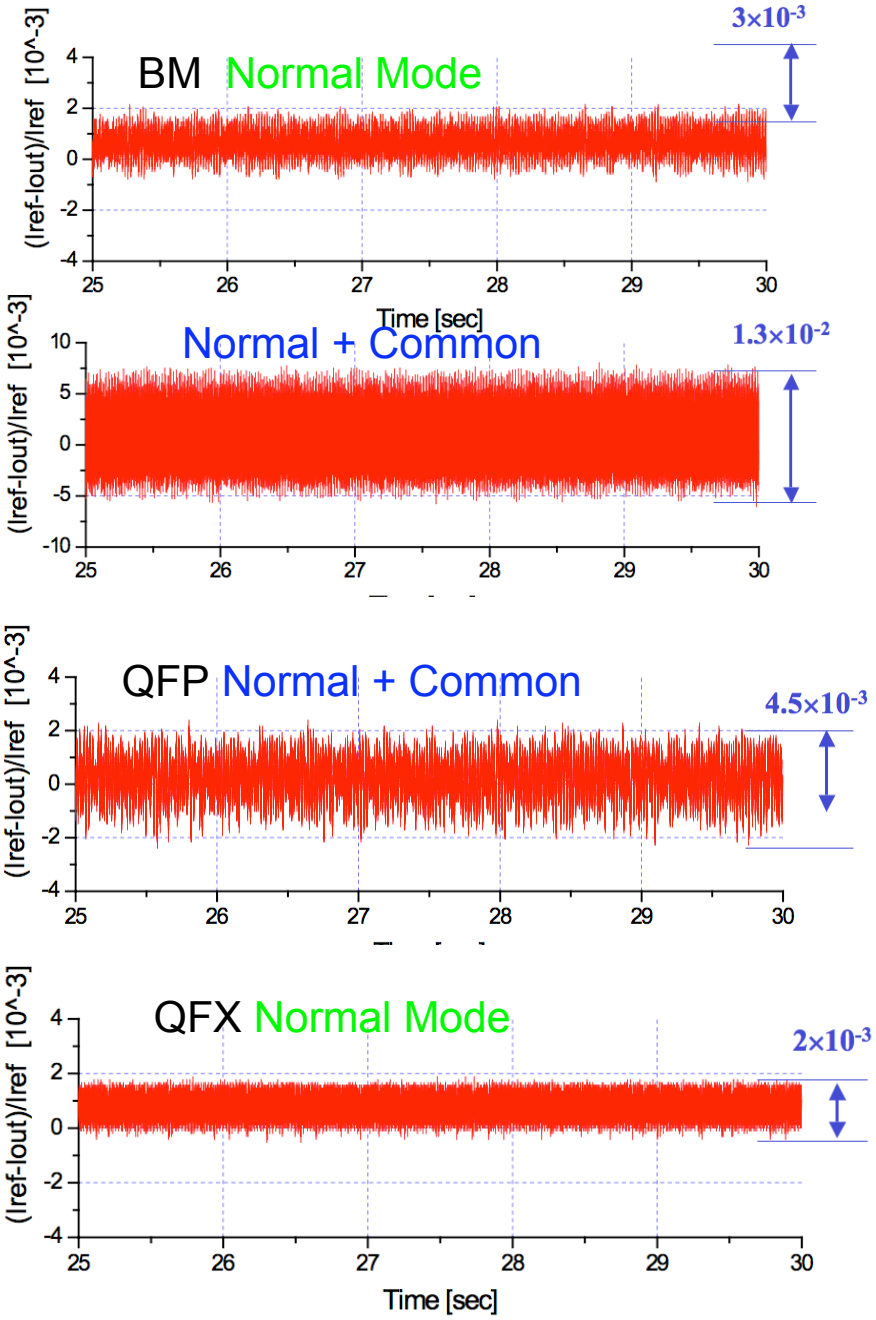
Time

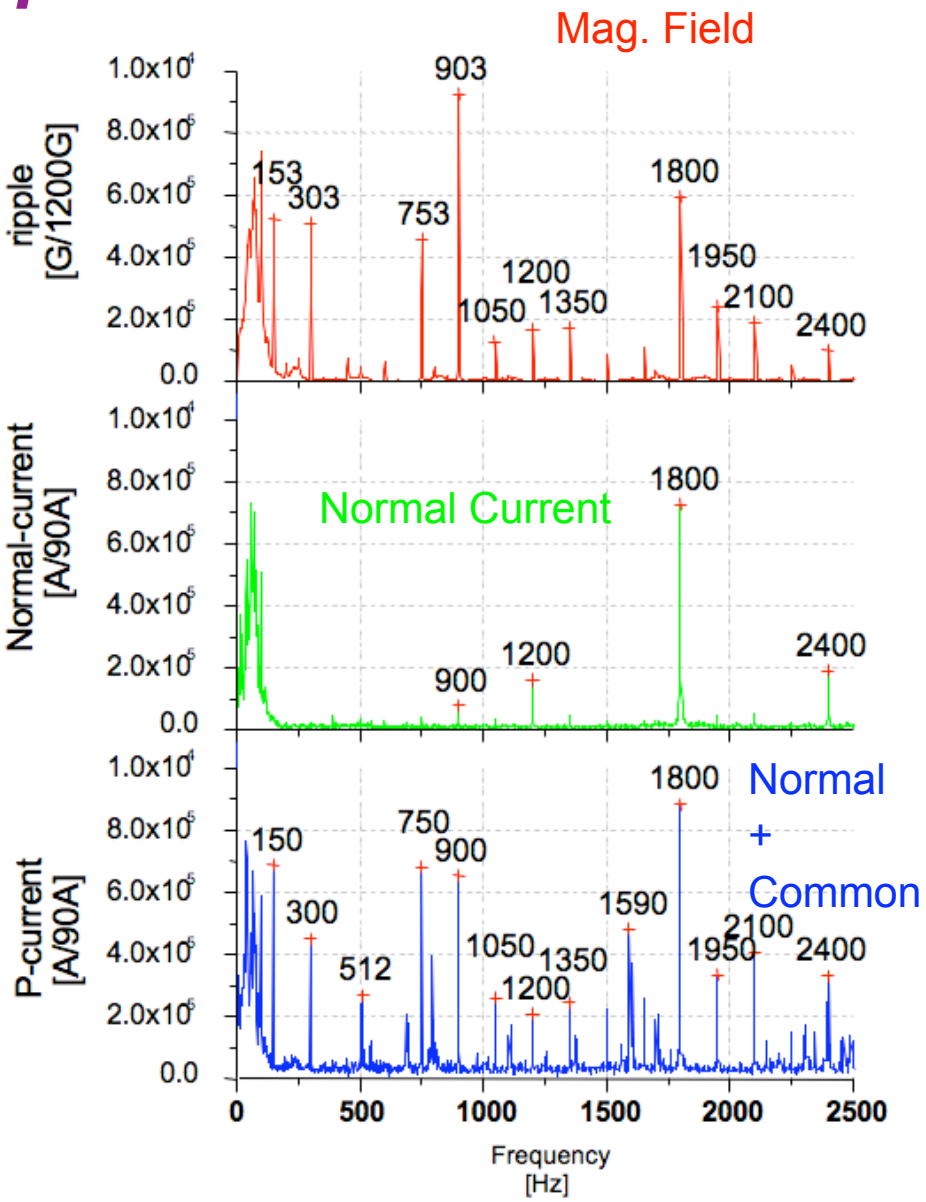



Normal Mode
電流の向き
144
143
090
089
072
071
UP
DN
電流の向き
基準電磁石
①
②／⑥
Common Mode
Arc : C
Arc : A
N2
DCCT
N1
BM1
①
BM5
⑥
BM6
②
" In " & " Out " should differ
Earth Line
Why there are so Many Patterns
Tandem of 6 Independent PS's
Interference of PS's Directly Appears on Magnets
018
017
216
215
162
161
Arc : B
BM3
④
BM4
③
BM2
⑤
周波数により場所毎＆
時間毎に異なる変化
多様な軌道パターンの発現

at 3 GeV Operation in May & June

Improvement





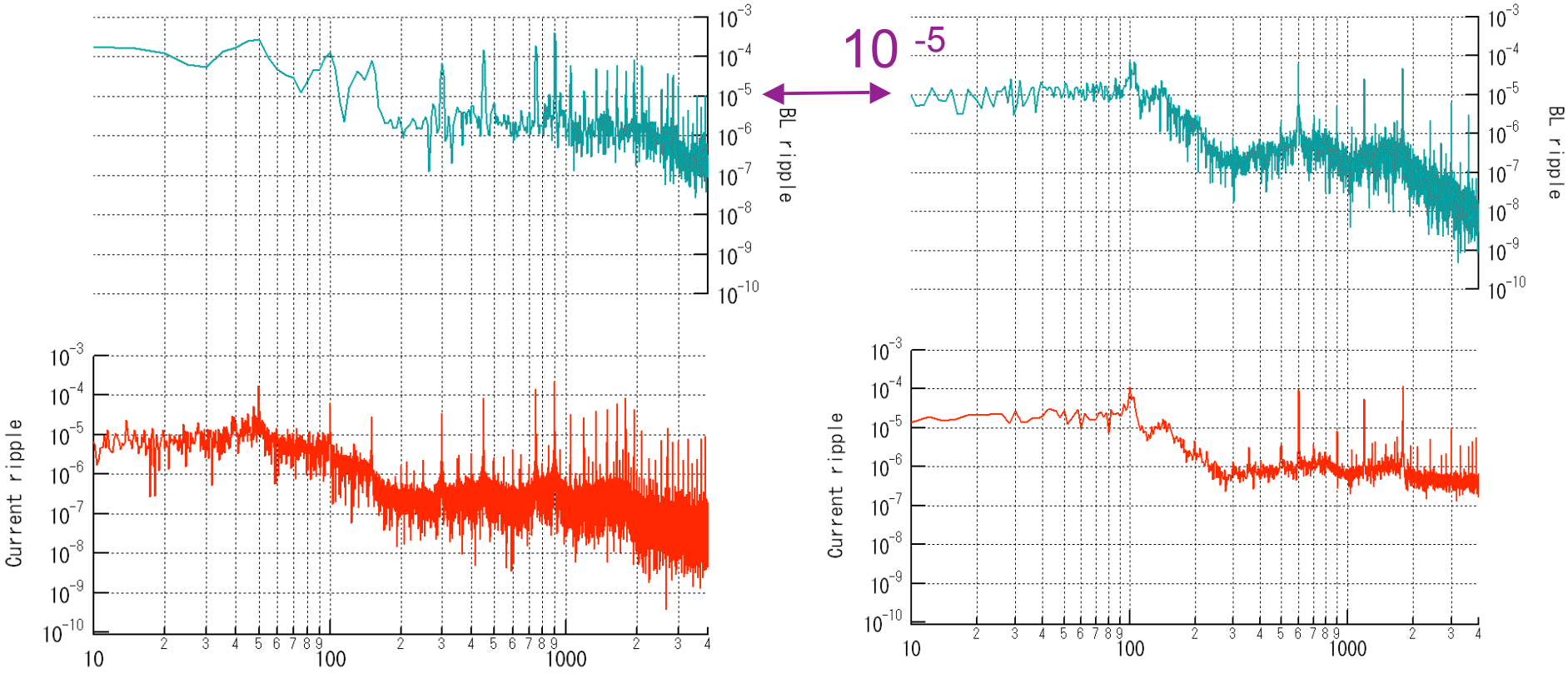
Ripples of QFX

Improvement of BM @ 3 GeV

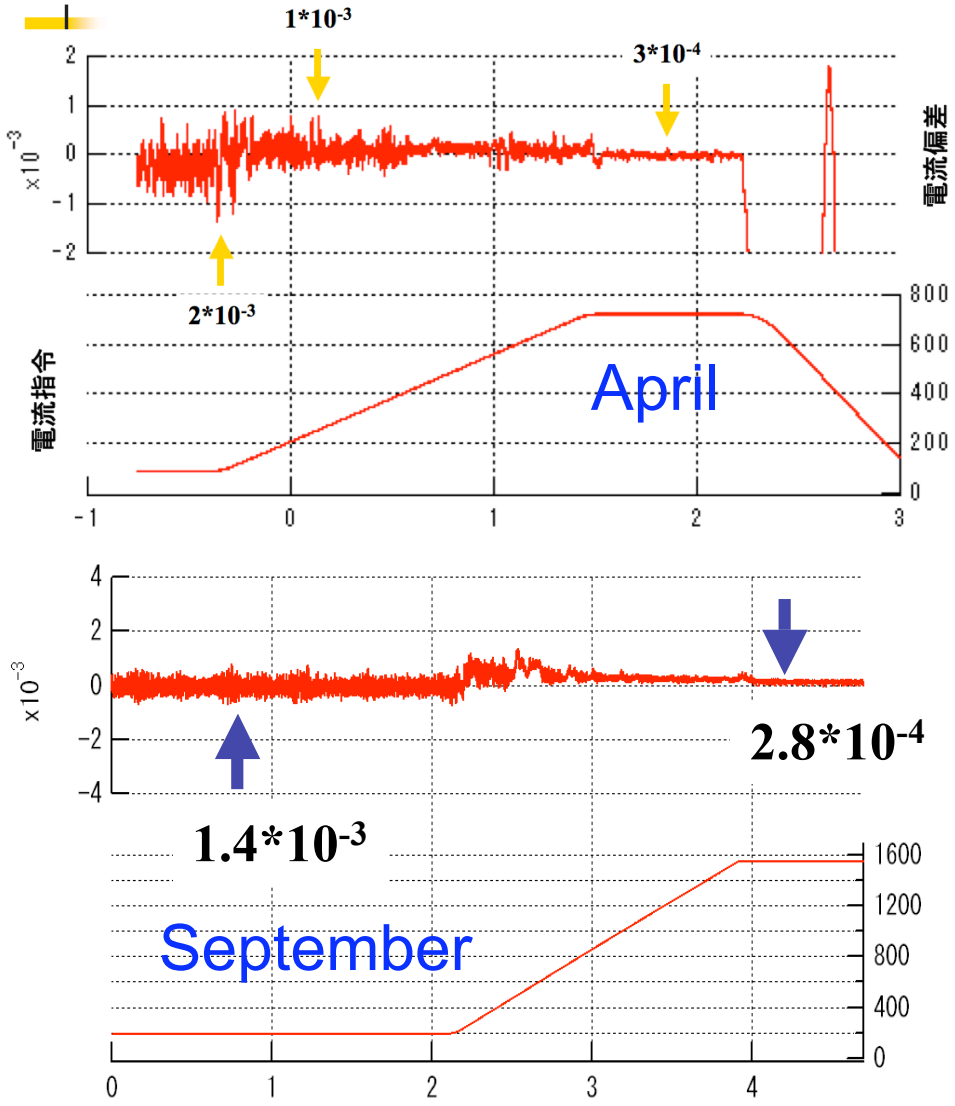
Ripple Spectrum of BM - PS

April 2008

September 2008



Improvement of BM Pattern Operation



1. Each PS powered 16 BM's Independently
2. Adjust Filter Constant
3. Add / Increase Capacitor to absorb Common Current
4. Add Resistor just at Output of PS

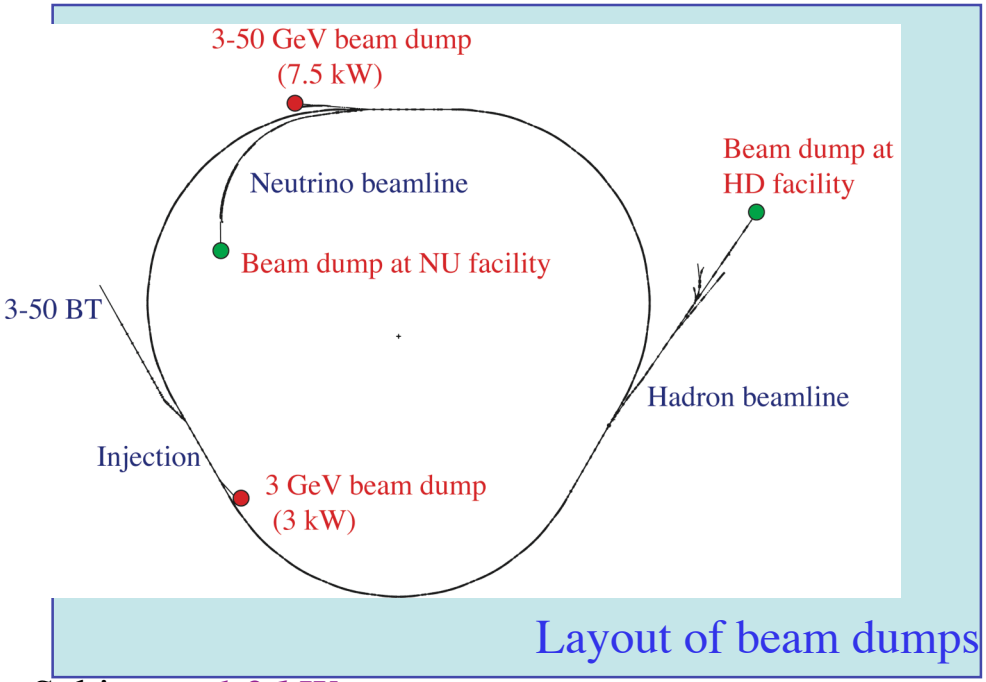
5. Add Resistor at Each Magnet (waiting)

Limit : $\Delta(BL)/(BL) =\sim 10^{-5}$

$\Delta\nu = 10^{-4}$ ------> $\Delta(QM)/QM = 3\times10^{-6}$ (1/30)

not taking account of Resonance Extraction

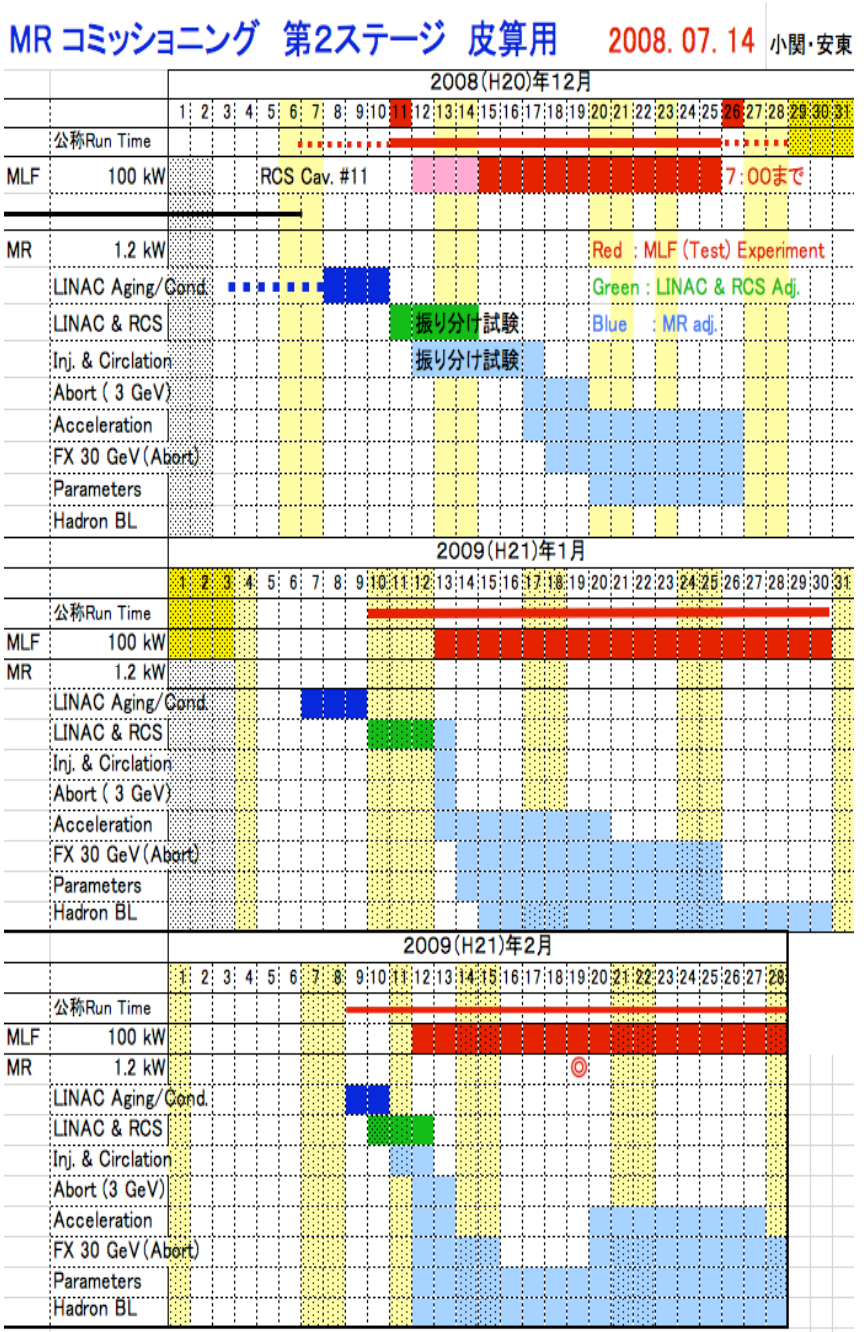
Procedure of 2nd stage beam commissioning



Layout of beam dumps

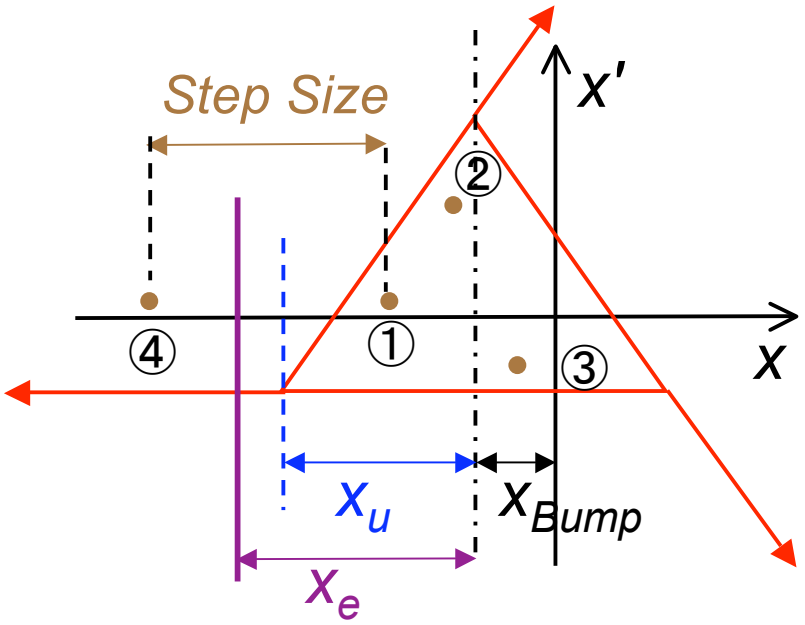
Subjects : ***1.2 kW***

1. Reproducibility of the previous RUN's
2. Acceleration and fast extraction to abort beam line
3. Beam extraction to hadron beam dump
   - Slow extraction ***without Ripple Control***
   - Extraction using FX kickers (if necessary)
4. Precise tuning and parameter measurements
   - Parameter measurements at 3 GeV
   - Parameter measurements at 30 GeV



Problems about Slow (Resonance) Extraction

Stability of Resonance Separatrix & Septum Position (COD & Bump Orbit)



Electric Septum

KEK-PS-MR

Δ(QM)/QM=1E-5 <--> Δν=7E-5

Δx=1 mm @ 0-Disp.

<--->Δ(B)/B=1E–3 @ 3 GeV

Trans. Emittance 15 π mm-mr @ 3 GeV

---> 15 *(4.08/33.0) = 1.85 π mm-mr @ 30 GeV

If Extraction Starts at ν-67/3 = 0.0067

for 2.5 π mm-mr

X_u = ~ 11 mm, $\delta X_u / \delta\nu$ = 1.65 (β_x = ~ 40 m)

SS : Step Size (3-Turn Separation) =~ 20 mm

(X_e = ~ - 40 mm)

< seems difficult, would be a few mm ?>

If δX_u = 1.0 (0.1) * SS

$\delta\nu$ = 0.012 (0.0012) / δ(QM)/QM=4E-4 (4E-5)

But if $\delta X_u \simeq X_u$, Beam is completely Lost.

i.e. $\delta\nu$ << 6.7E-3, δ(QM)/QM << 2.2E-4

This seems

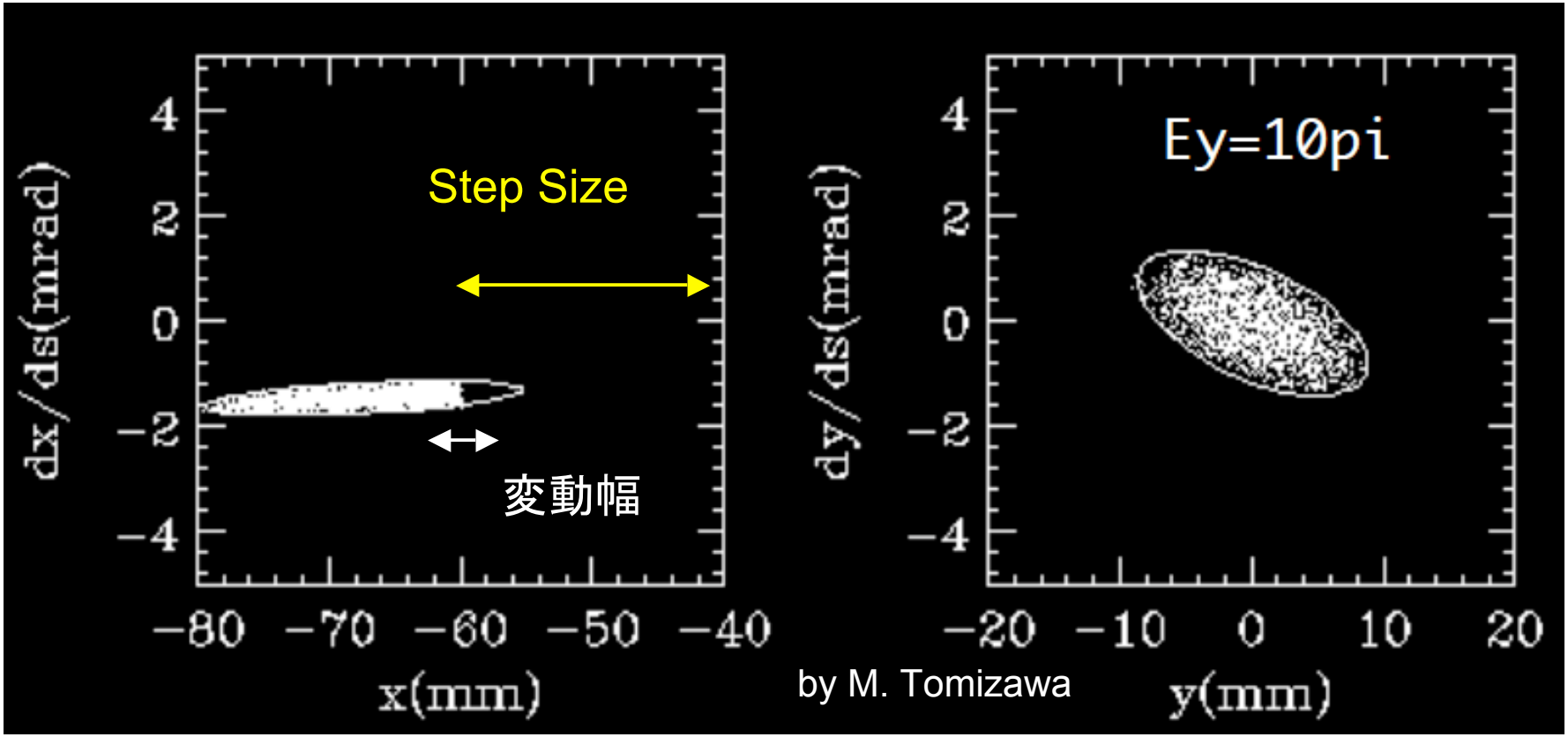
Near the Limit of Present Improvement

Slow Extraction

Suppose Coherent Δ(QM)/QM= ±0.01 % = ±1.0E-4 (δν= ±0.003),

Variation of Fixed Point of Separatrix @ ESS is ± 5 mm.

If we can control that Step Size be ~ 20 mm, SX may work



100 kW / 0.3 Hz is Ready ?

1. Just 30 GeV Acceleration will be done.

2. ***If Resonance Width < ± -0.02***、and

・***Realize Tune Variation < ± -0.01*** (Coherent QM Variation < ± *0.03 %*),

・Set $(\nu_x, \nu_y) = \sim (22.15, 20.70)$ 、

100 kW @ *0.3 Hz / 6 Bunches* (***Full Tune Spread : ∽0.16***)

will be accelerated @ 30 GeV.

3. **30 GeV Extraction**

Fast Extraction : probably OK

God knows the Control of $3\nu_x = 67$ *Resonance*

Separatrix & Complex Variation of Orbit & Extraction Step Size

Separatrix Variation < ±1 mm<==>*Tune Variation* < ± *6.1E-4*

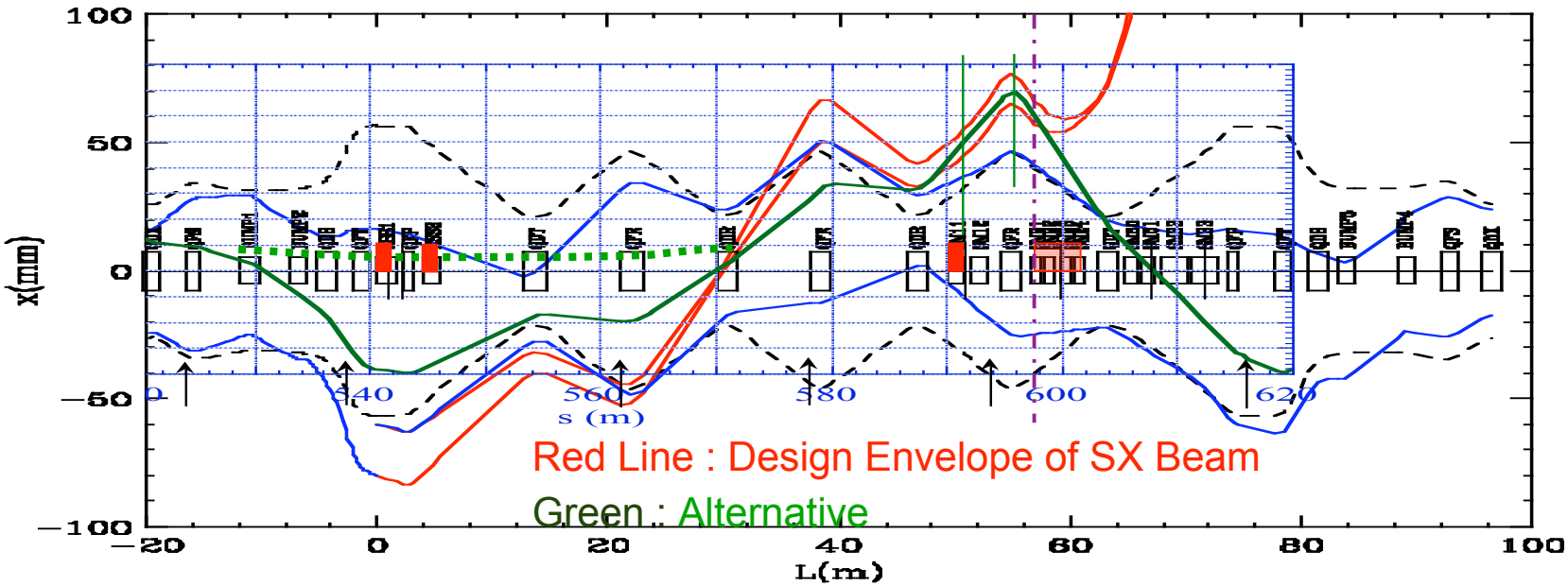
(QM Variation < ± *2.0E-5*)

Backup / Alternative Menu of Beam Extraction to Hadron Dump

1. Fast Extraction by FX - Kicker & Bump Orbit (and also Steering Mag.)
2. Squeeze Coasting Beam @ ESS by Bump Orbit

   Beam Loss : a few tens Watt for < 1 mSv/h

   From KEK-PS-MR & RCS Operation (preliminary)



FX-Kicker + Bump + Local Bump by Steering Mag.

But this does not work because Steering Mag. needs 4 times Stronger Kick than the maximum. ----> Now in Hard Study

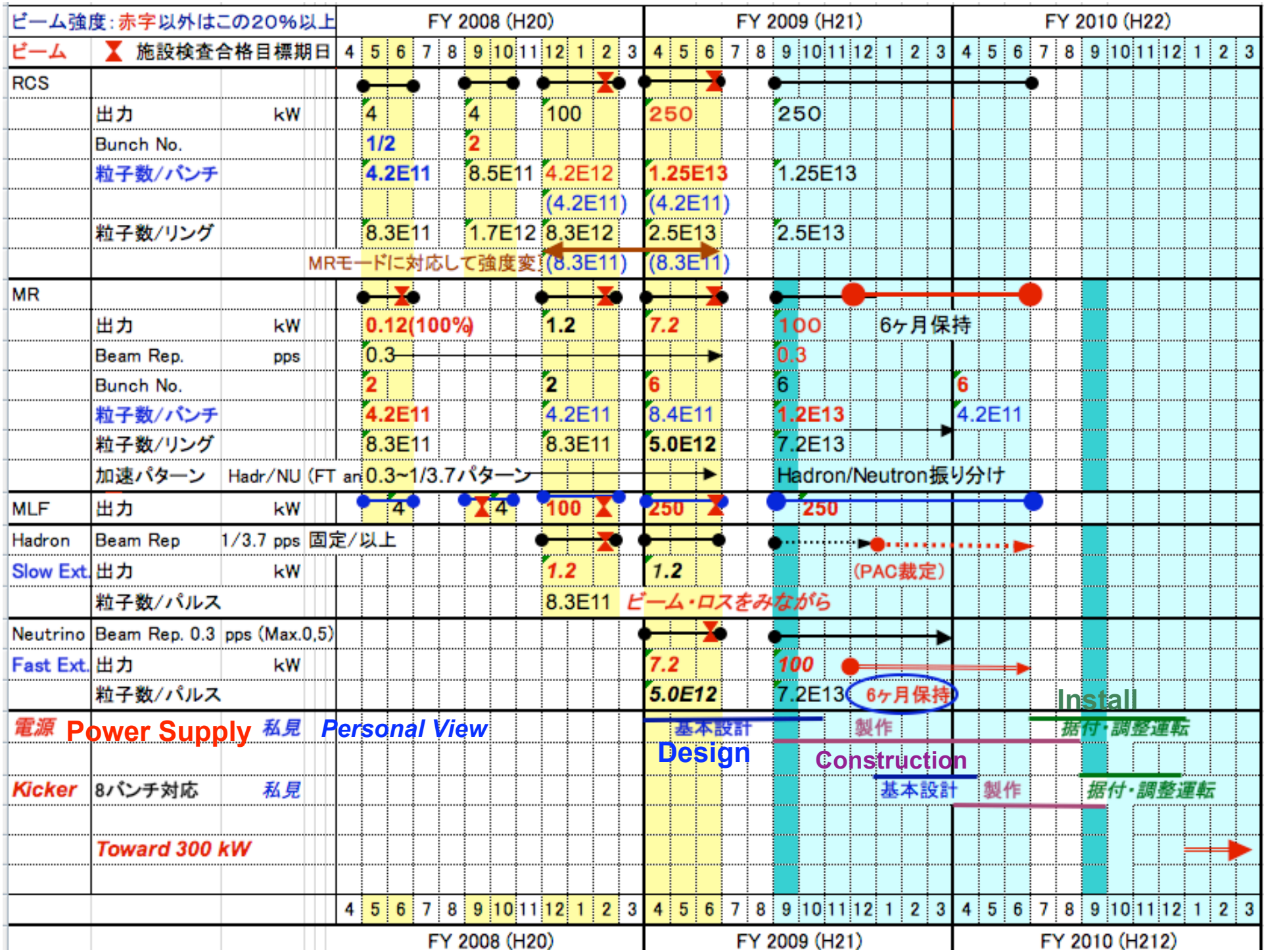
Expectation / Desire for Extraction to Hadron

1. What will be will be clear When it will be done.
2. Anyway Slow Extraction must be tried even though 100 % modulation.
3. Any Performance is determined by Beam Loss Issue because of Residual Radiation Level.
4. With the Present Structure of Main Power Supplies, Slow Extraction will be able to be considered quantitatively with Ripple and Spill Feedback.

Without Essential / Fundamental Improvement / Replacement,

Stable / Reliable Slow Extraction could not be discussed.

Also > 100 kW Beam Power @ Fast Extraction


ビーム強度：赤字以外はこの20%以上
FY 2008 (H20)
FY 2009 (H21)
FY 2010 (H22)
ビーム
施設検査合格目標期日
4 5 6 7 8 9 10 11 12 1 2 3
RCS
出力 kW
4 4 100 250 250
Bunch No.
1/2 2
粒子数/バンチ
4.2E11 8.5E11 4.2E12 1.25E13 1.25E13
(4.2E11) (4.2E11)
粒子数/リング
8.3E11 1.7E12 8.3E12 2.5E13 2.5E13
MRモードに対応して強度変更
(8.3E11) (8.3E11)
MR
出力 kW
0.12(100%) 1.2 7.2 100 6ヶ月保持
Beam Rep. pps
0.3 0.3
Bunch No.
2 2 6 6 6
粒子数/バンチ
4.2E11 4.2E11 8.4E11 1.2E13 4.2E11
粒子数/リング
8.3E11 8.3E11 5.0E12 7.2E13
加速パターン Hadr/NU (FT an
0.3~1/3.7パターン
Hadron/Neutron振り分け
MLF
出力 kW
4 4 100 250 250
Hadron
Beam Rep 1/3.7 pps 固定/以上
Slow Ext.
出力 kW
1.2 1.2
(PAC裁定)
粒子数/パルス
8.3E11
ビーム・ロスをみながら
Neutrino
Beam Rep. 0.3 pps (Max.0,5)
Fast Ext.
出力 kW
7.2 100
粒子数/パルス
5.0E12 7.2E13
6ヶ月保持
Install
電源 Power Supply 私見 Personal View
基本設計 製作 据付・調整運転
Design Construction
Kicker
8バンチ対応 私見
基本設計 製作 据付・調整運転
Toward 300 kW
FY 2008 (H20)
FY 2009 (H21)
FY 2010 (H212)