Measurement of Longitudinal Motion at 150MeV FFAG

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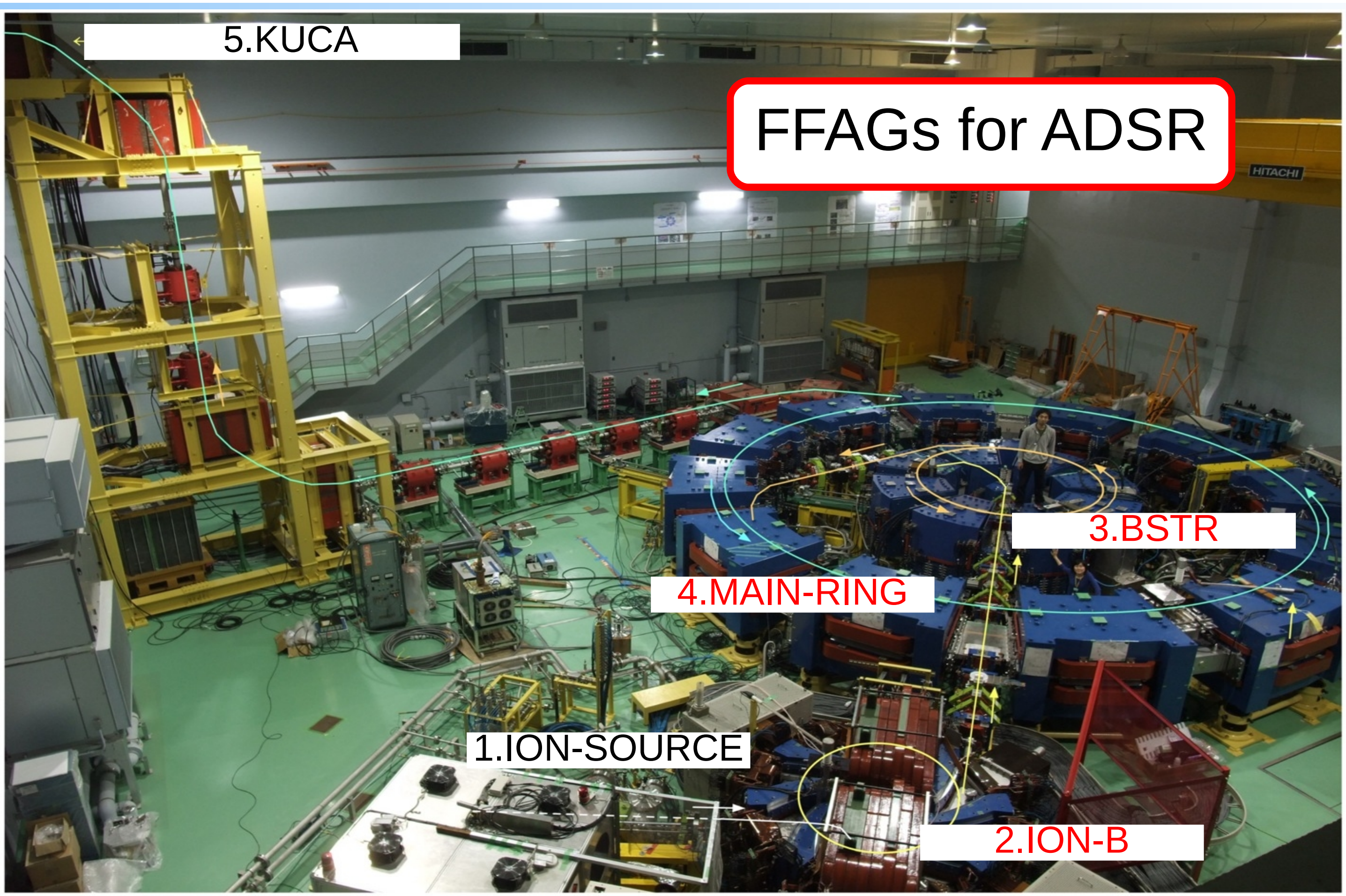
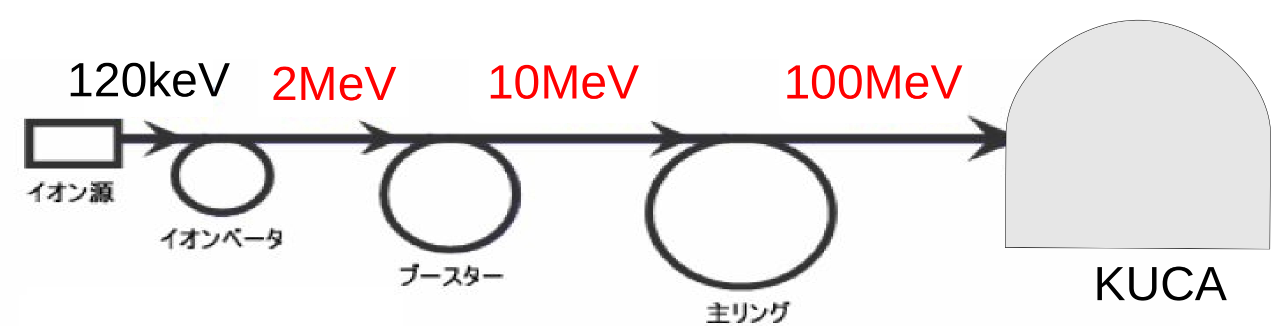
Outline

- FFAG accelerators for ADSR
- Transparency of 150MeV FFAG Ring at KURRI
- Measurement of Longitudinal Motion
- Analysis of Synchrotron oscillation
- Summary & Next step

FFAGs for ADSR





FFAG for ADSR

Three step acceleration

1.ION-SOURCE

2.ION-B

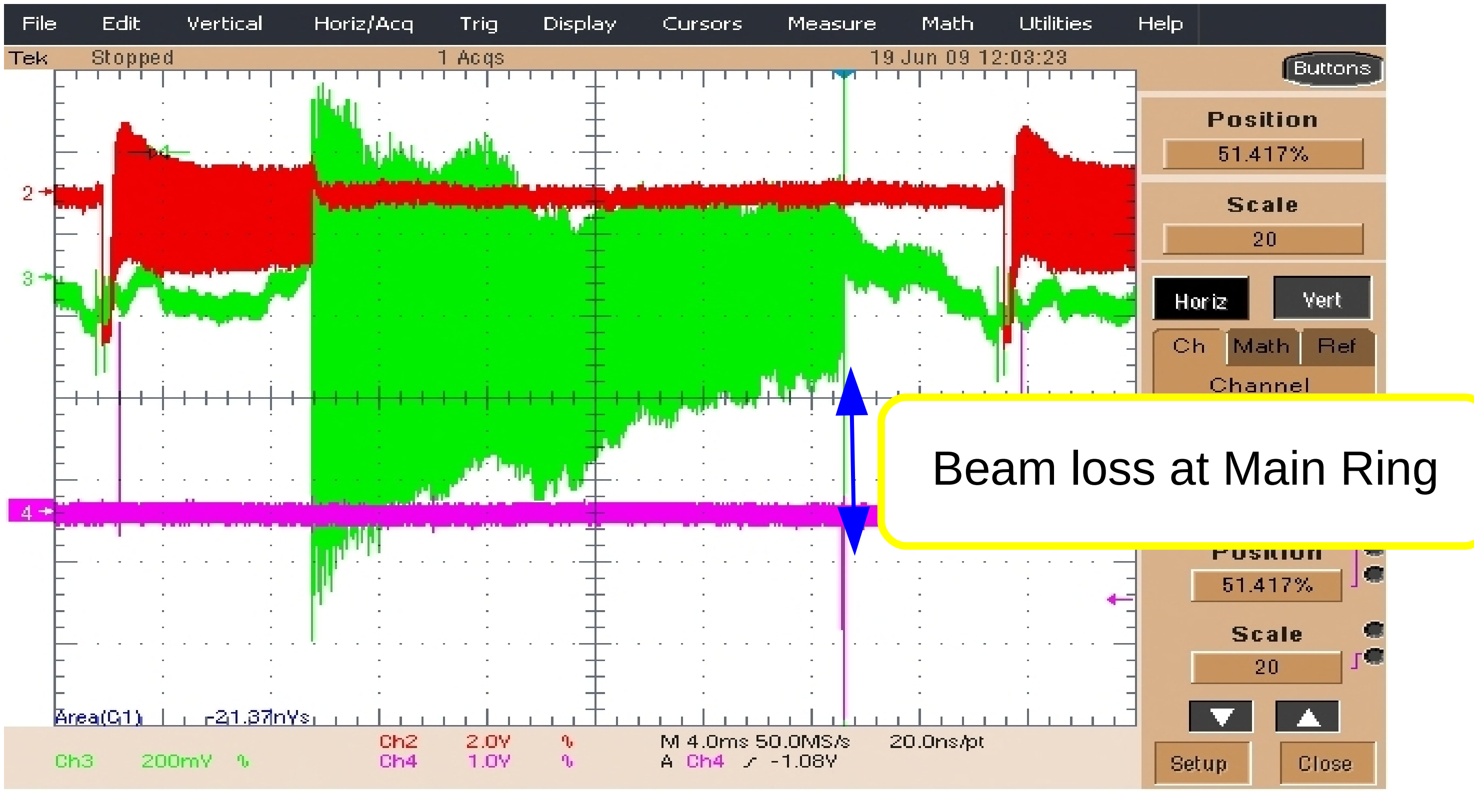
3.BSTR

4.MAIN-RING

Producing neutron by irradiating proton beam to target

5.Neutron is supplied for KUCA

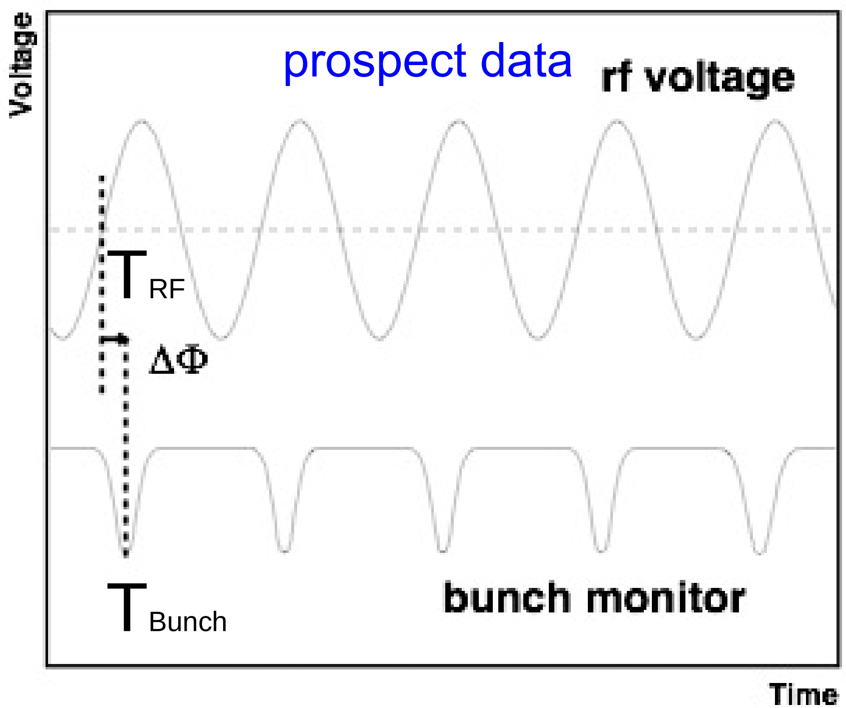
Transparency of 150MeV FFAG at KURRI



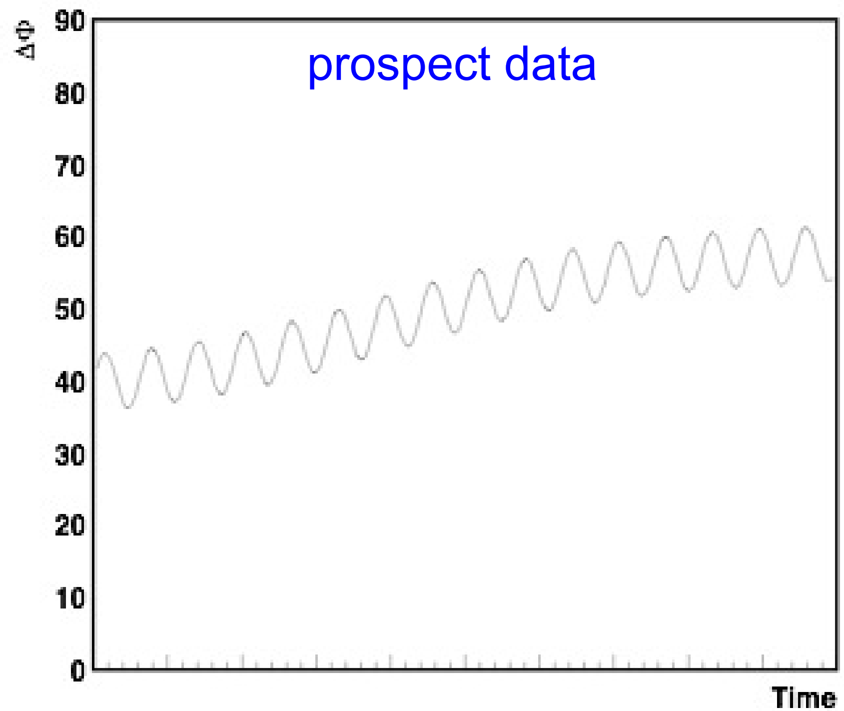
Longitudinal instability？

Experimentally, obtain real ϕs

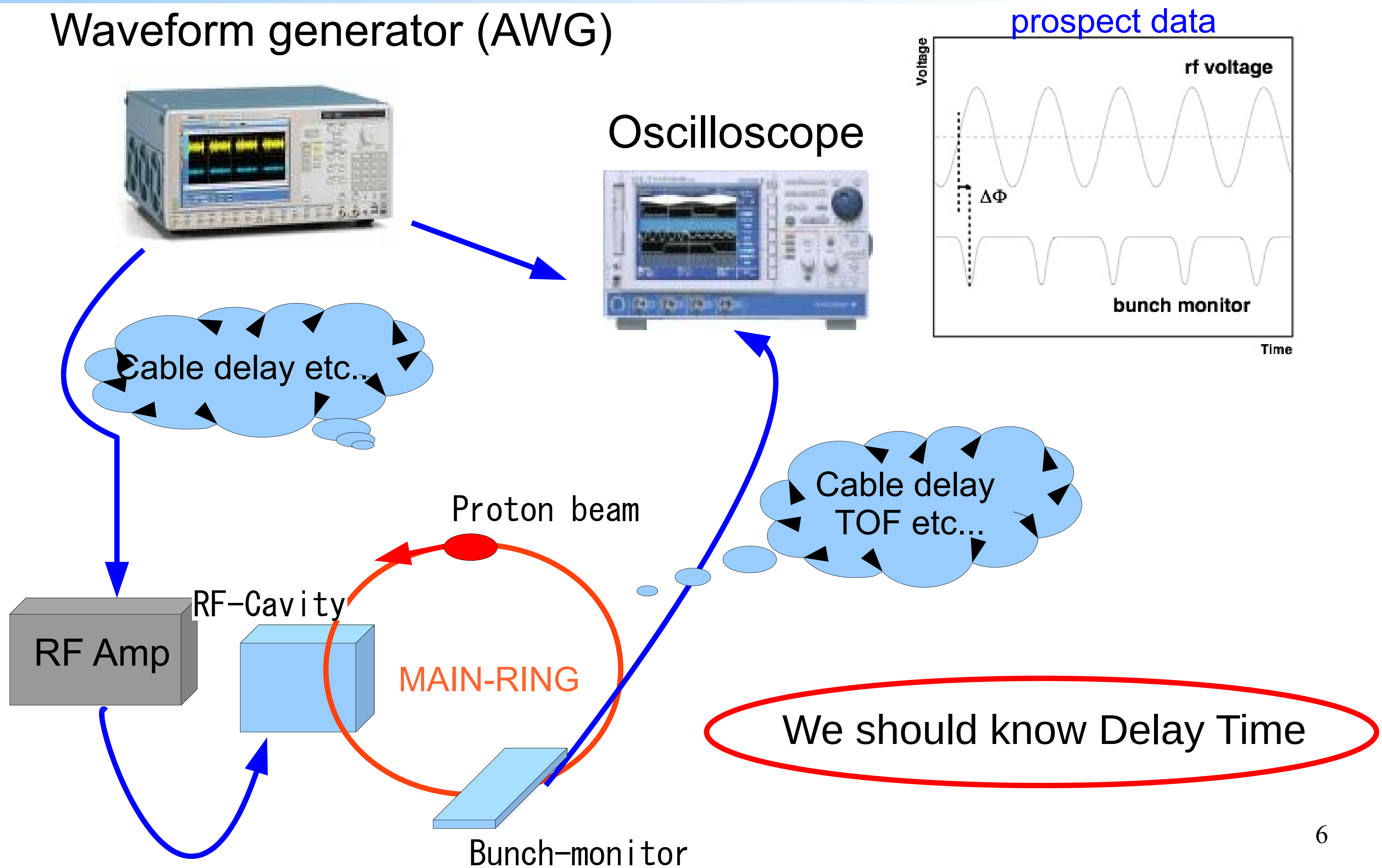
Measurement Scheme of Longitudinal Motion



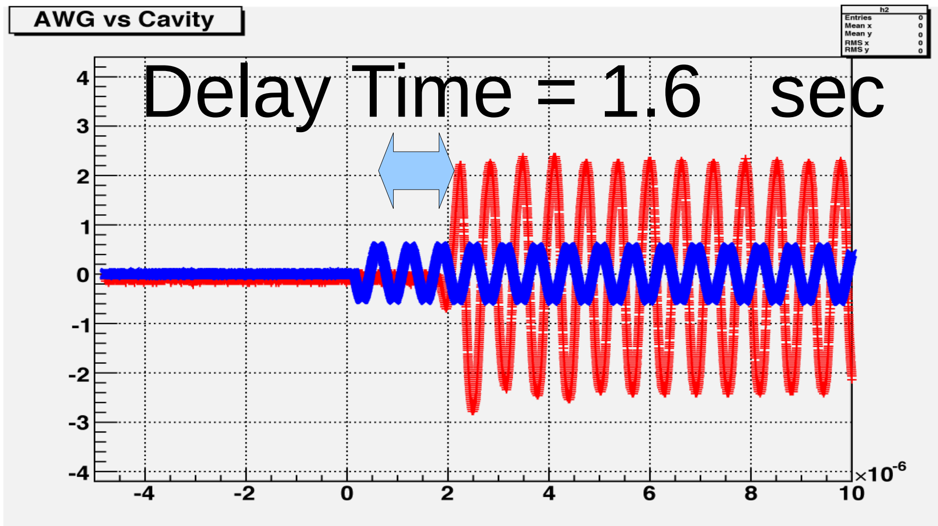
$$\Delta\Phi \longleftrightarrow 2 \quad x \ (T_{Bunch} - T_{RF})/T_{rev}$$



Experimental setup

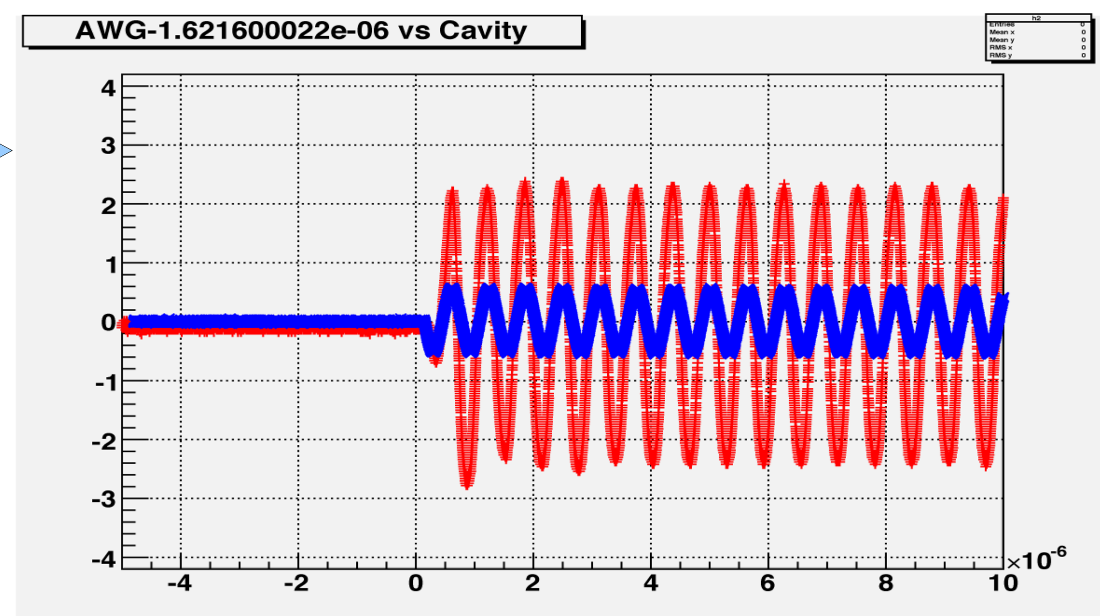


Measurement of Delay Time

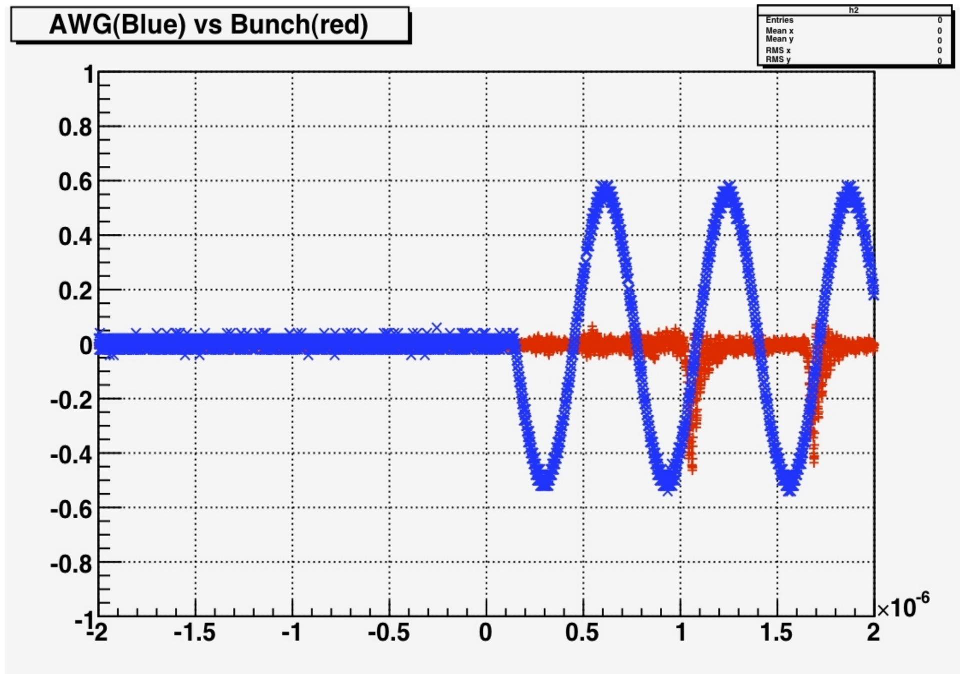


Red -> Cavity-RF
Blue -> Wave form generator(AWG)

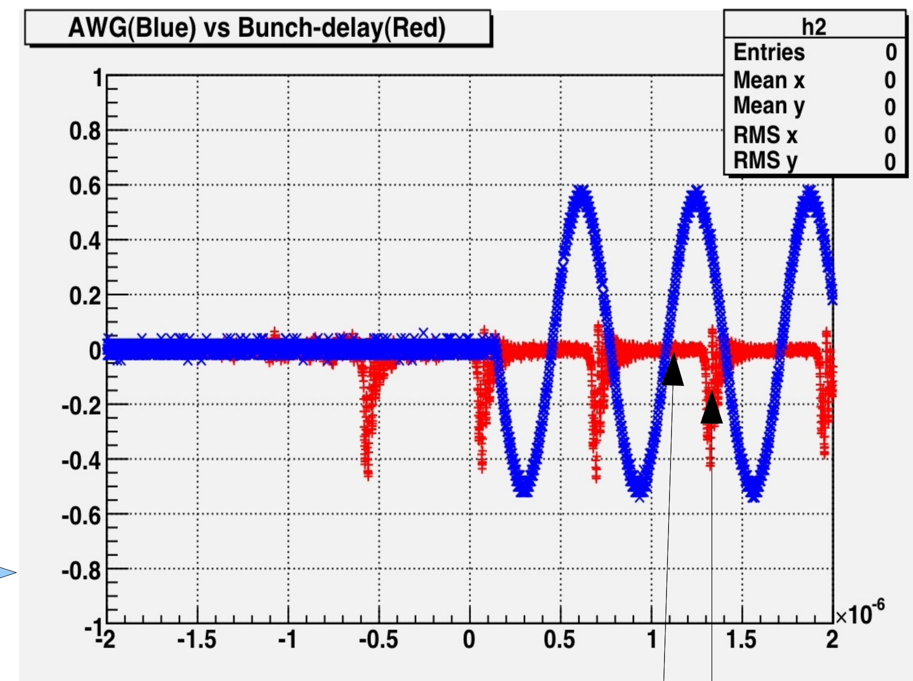
After correction
of delay time



Beam Bunch v.s
Output of wave form generator (AWG)



Red-> Bunch Beam
Blue-> AWG-RF

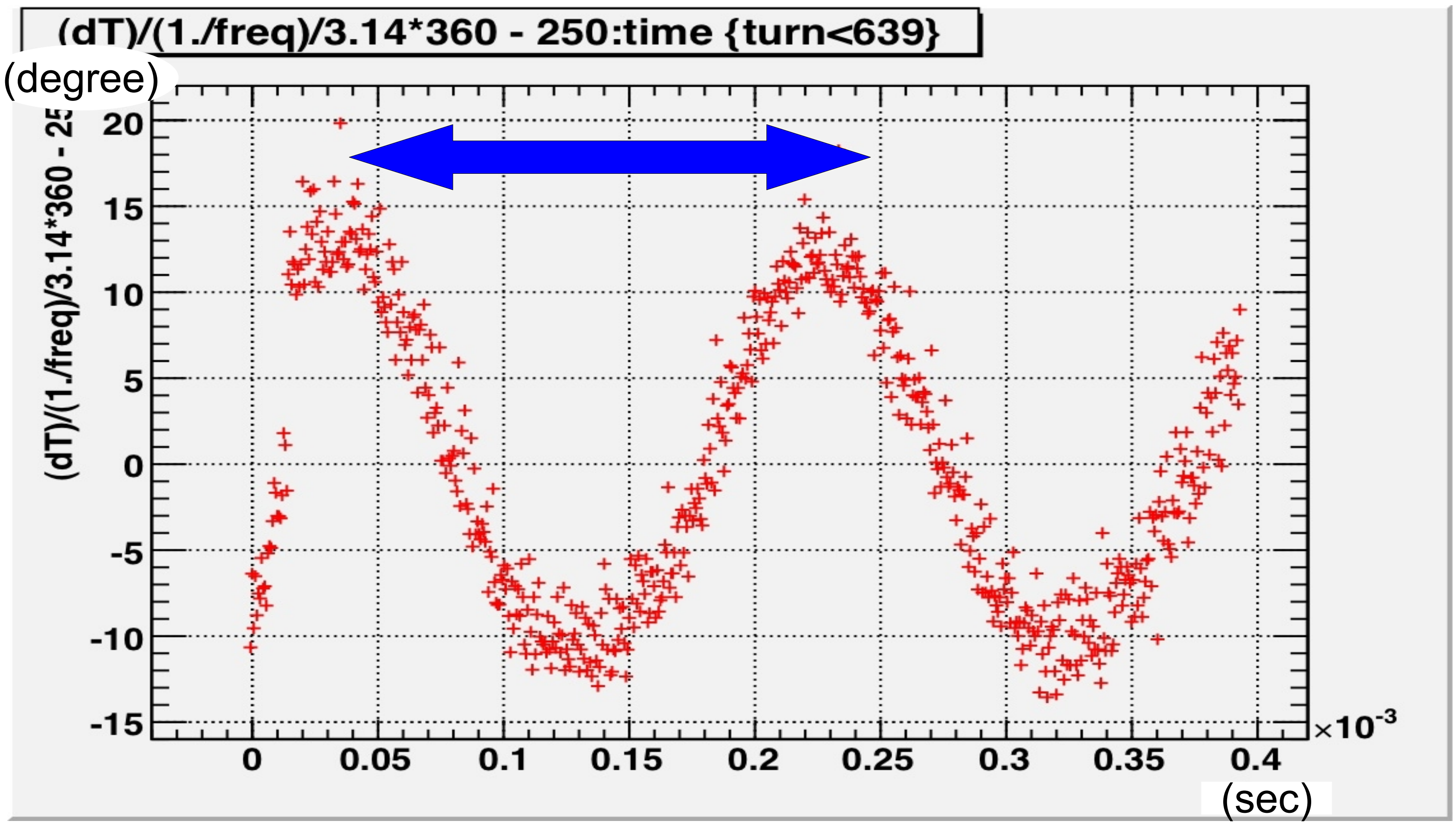


Correction of Delay time (1.6μsec)

$T_{Bunch} - T_{RF}$

$\Delta\Phi \longleftrightarrow 2 \quad x\ (T_{Bunch} - T_{RF})/T_{rev}$

Synchrotron oscillation



synchrotron oscillation frequency → 4.3kHz

Estimation of Synchrotron oscillation frequency

Parameter of Main Ring

$$\frac{\omega_0}{2\pi} = \frac{\omega_s}{2\pi\beta_s} = 10.2$$ [MHz]

$$eV = 2$$ [keV]

$$\eta = -0.709$$

$$\phi_s = 50$$ [deg]

$$E_s = 938.340 + 11.6$$ [MeV]

$$\Omega_s = \frac{\omega_0}{2\pi}\sqrt{\frac{-eV\,\eta\cos\phi_s}{2\pi E_s}}$$

Ω_s = 4.39kHz

Good Agreement between analysis and calculation

Analysis result 4.3kHz

Calculation result 4.39kHz

Summary

Propose new method to obtain real s

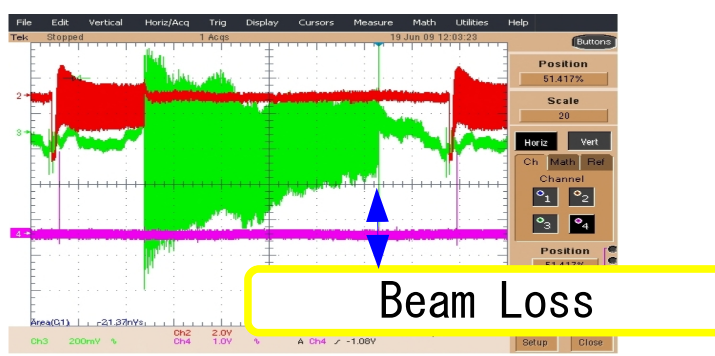
Using obtained ,Synchrotron oscillation frequency was calculated,experimentally

Since good agreement between analytic value and experimental value, new method has been confirmed

Next Step

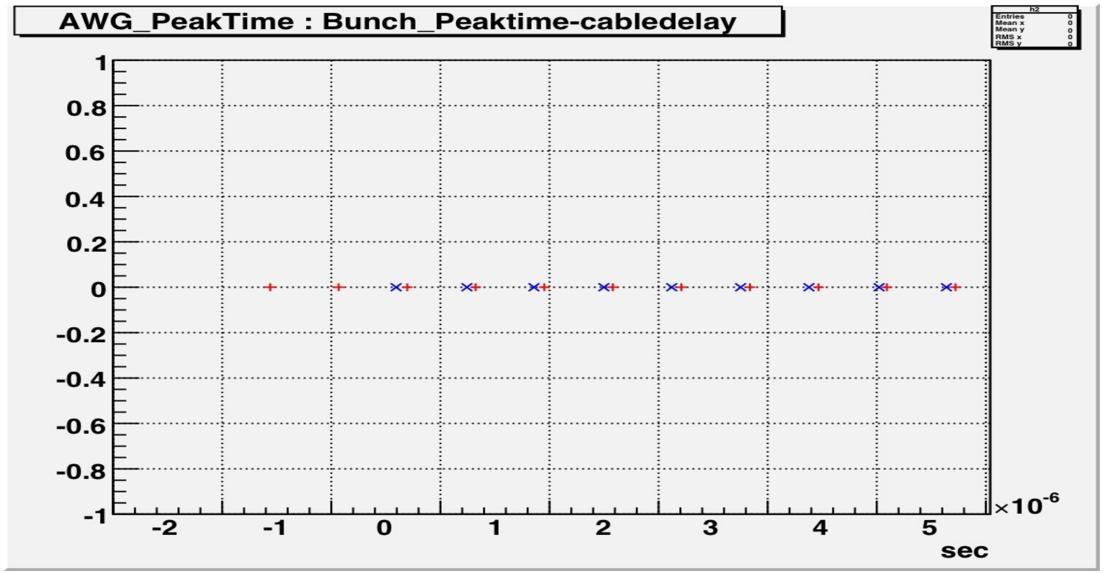
Proceed the analysis to obtain real Φs

Optimize the RF pattern to avoid beam loss



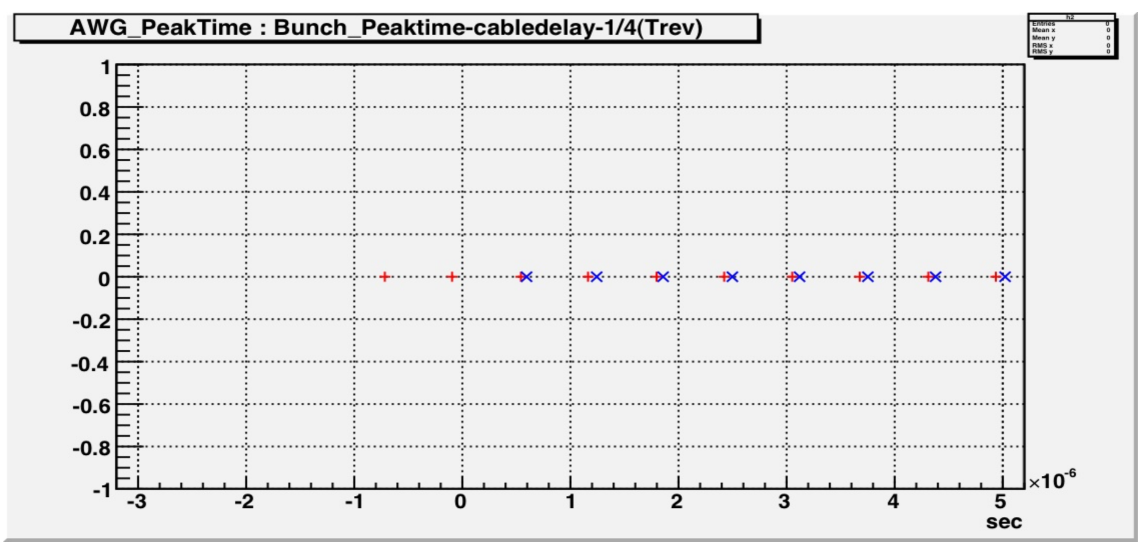
付録

Peak　Bunch timeとPeak RF timeの cable delay TOF 後の関係

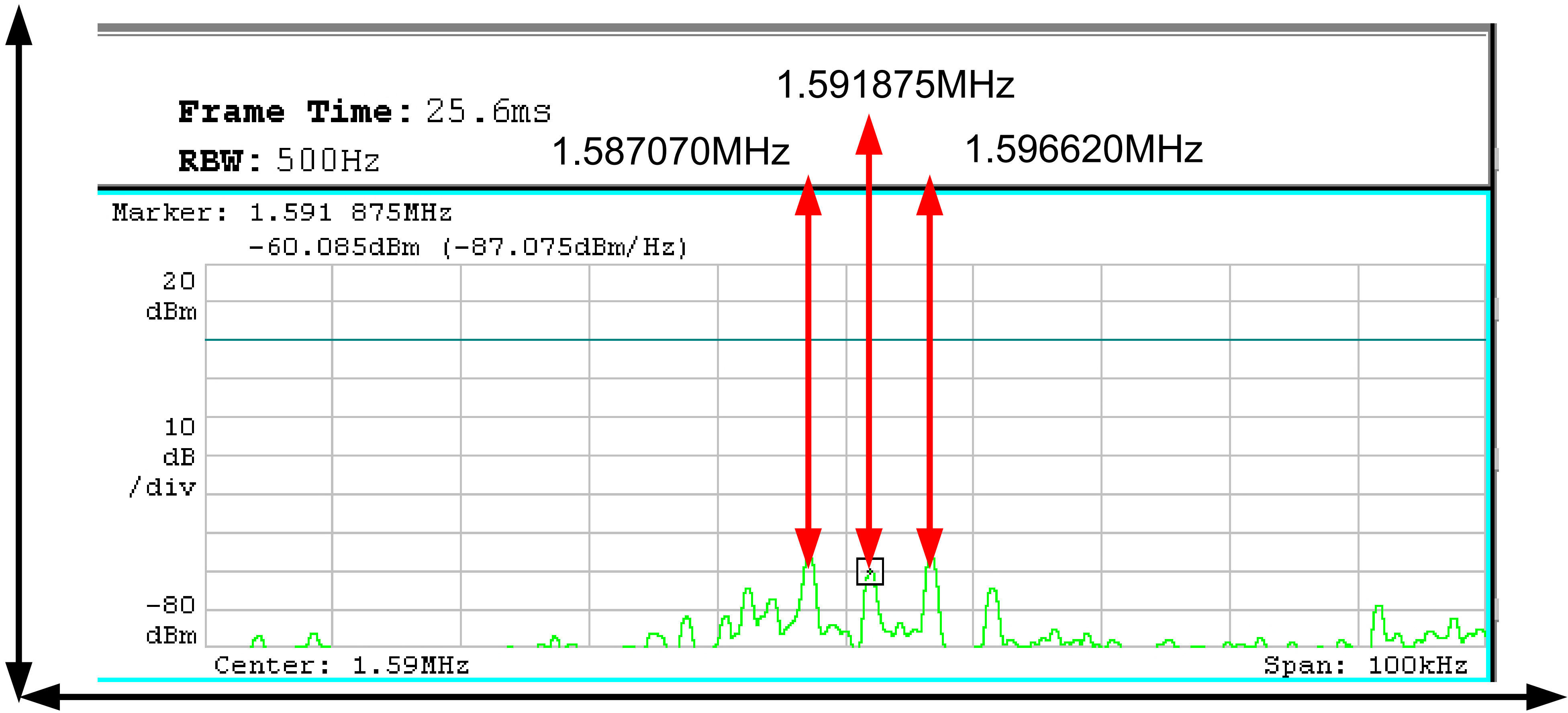


Red-> Peak Bunch time
Blue-> Peak AWG-RF time

Cable delay
&TOF (1/4)T_{rev}



synchrotron oscillation measurement using Realtime spectrum analyzer



synchrotron oscillationL_side 4.8kHz
synchrotron oscillationR_side 4.7kHz

位相安定性の原理とは

$$B(r)=B_0\left(\frac{r}{r_0}\right)^k$$

$$\alpha_p=\frac{dL/L}{dp/p}=\frac{1}{k+1}$$

α_p :モーメンタムコンパクション
L :平衡軌道
p : 運動量
η :スリップファクター

$$T=\frac{L}{v} \qquad \frac{dT}{T}=\frac{dL}{L}-\frac{dv}{v}$$

$$\frac{dv}{v}=\frac{1}{\gamma^2}\frac{dp}{p} \qquad \frac{dT}{T}=\left(\frac{1}{\gamma^2}-\alpha_p\right)\frac{dp}{p}=\eta\frac{dp}{p}$$

$$\eta=\frac{1}{\gamma^2}-\frac{1}{k+1}$$

式中のk値による、モーメンタムコンパクション
及びスリップファクターの値が
シンクロトロン振動の挙動を決定する。