Waseda University
Research Institute for Science and Engineering

3-Dimensional Profile Monitor Based on a Pulse Storage in an Optical Cavity for Multi-bunch Electron Beam

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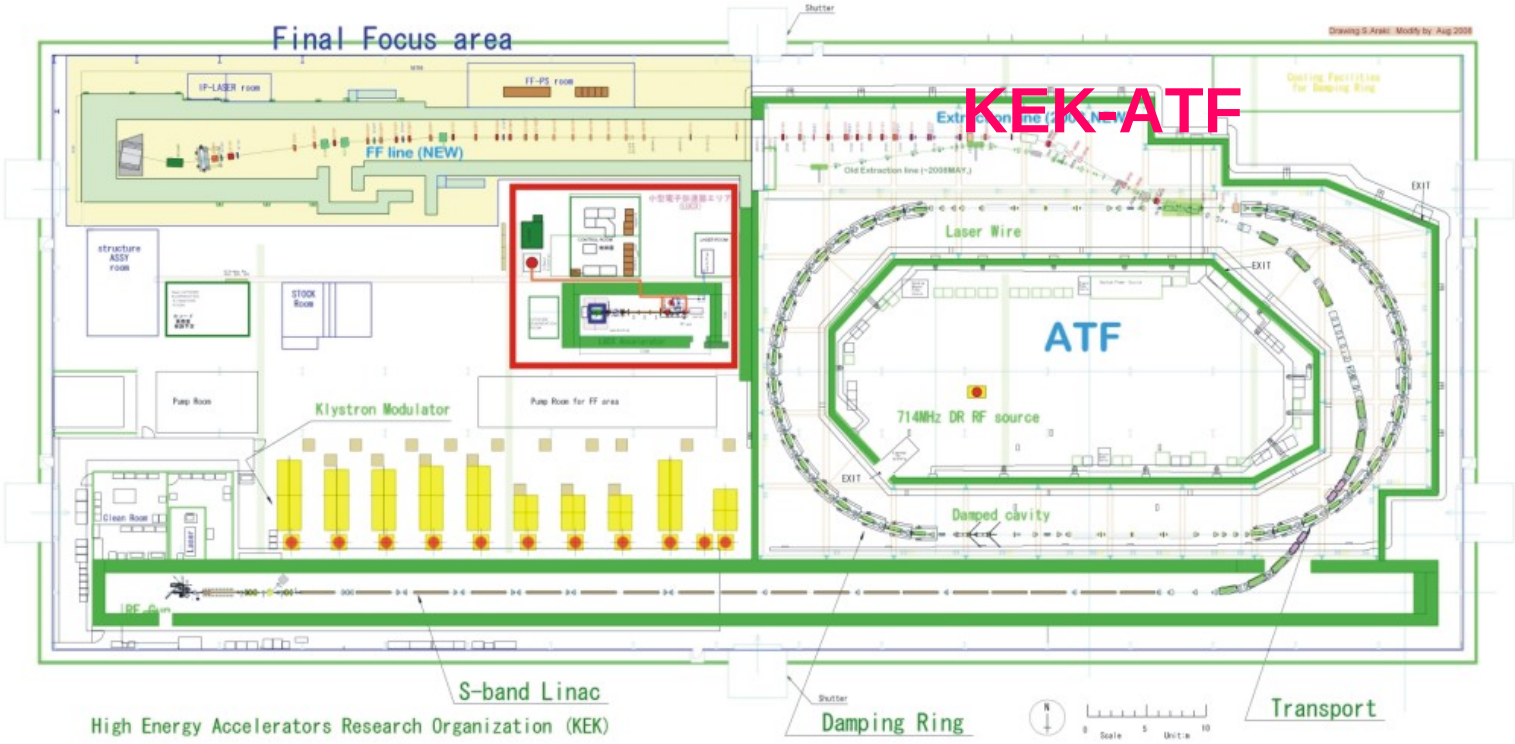
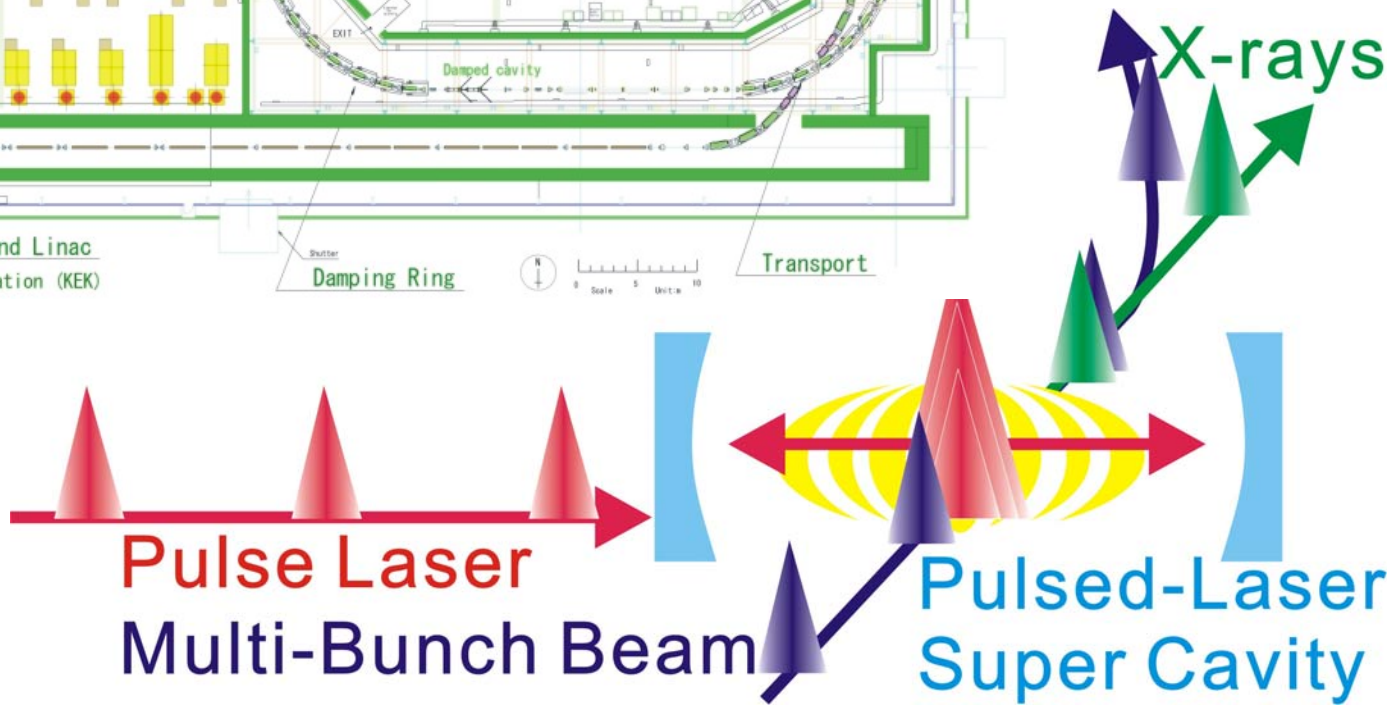
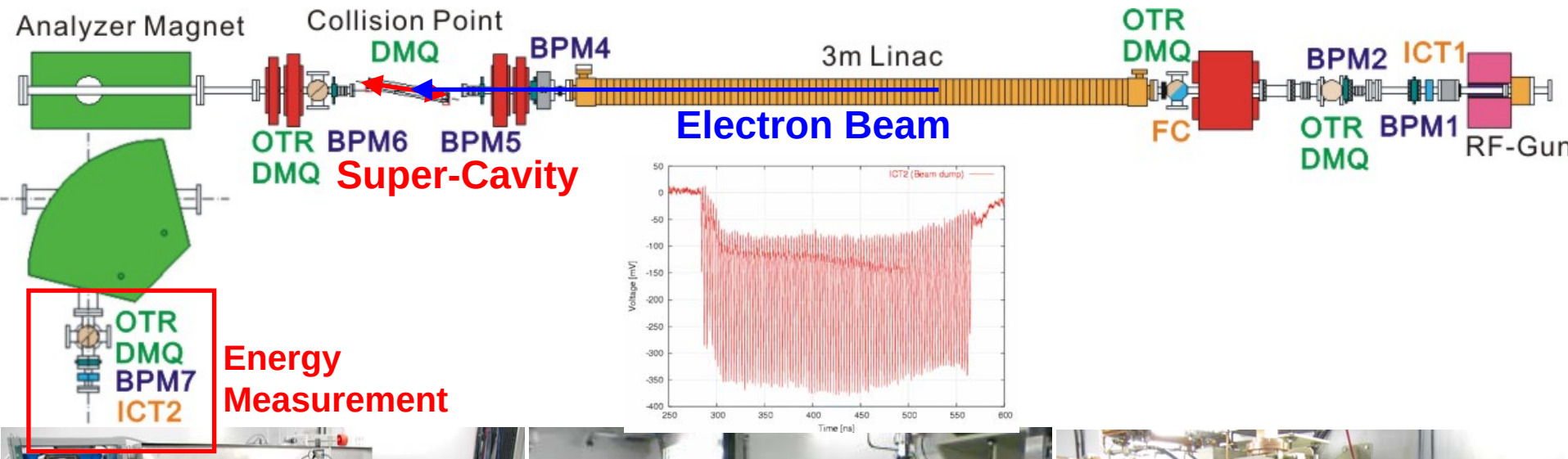
Location of LUCX Accelerator

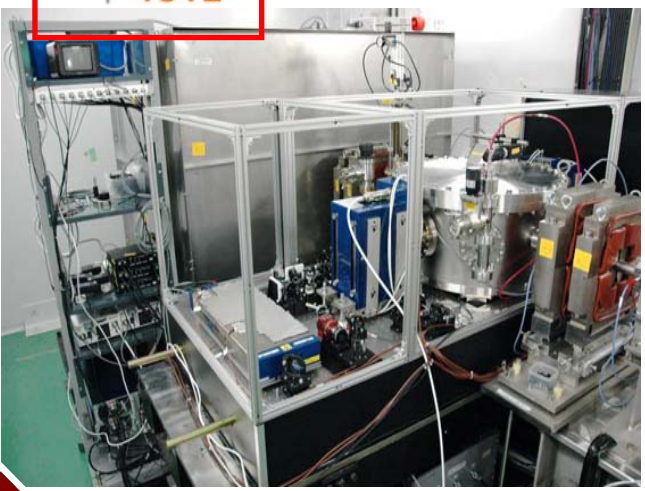


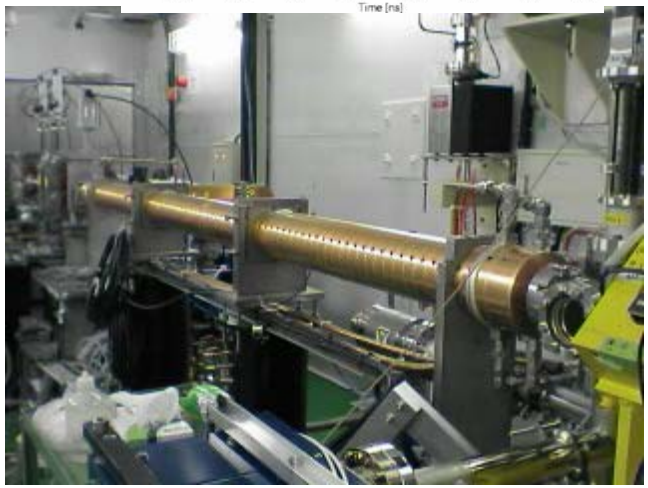


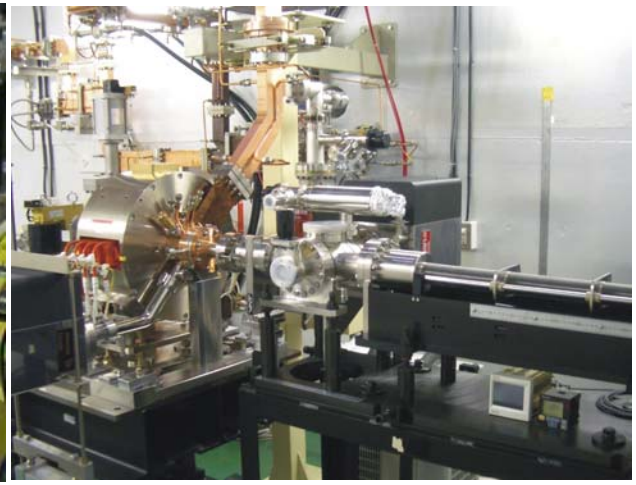
Multi-Bunch Electron Linac

LUCX Multi-Bunch Electron Linac



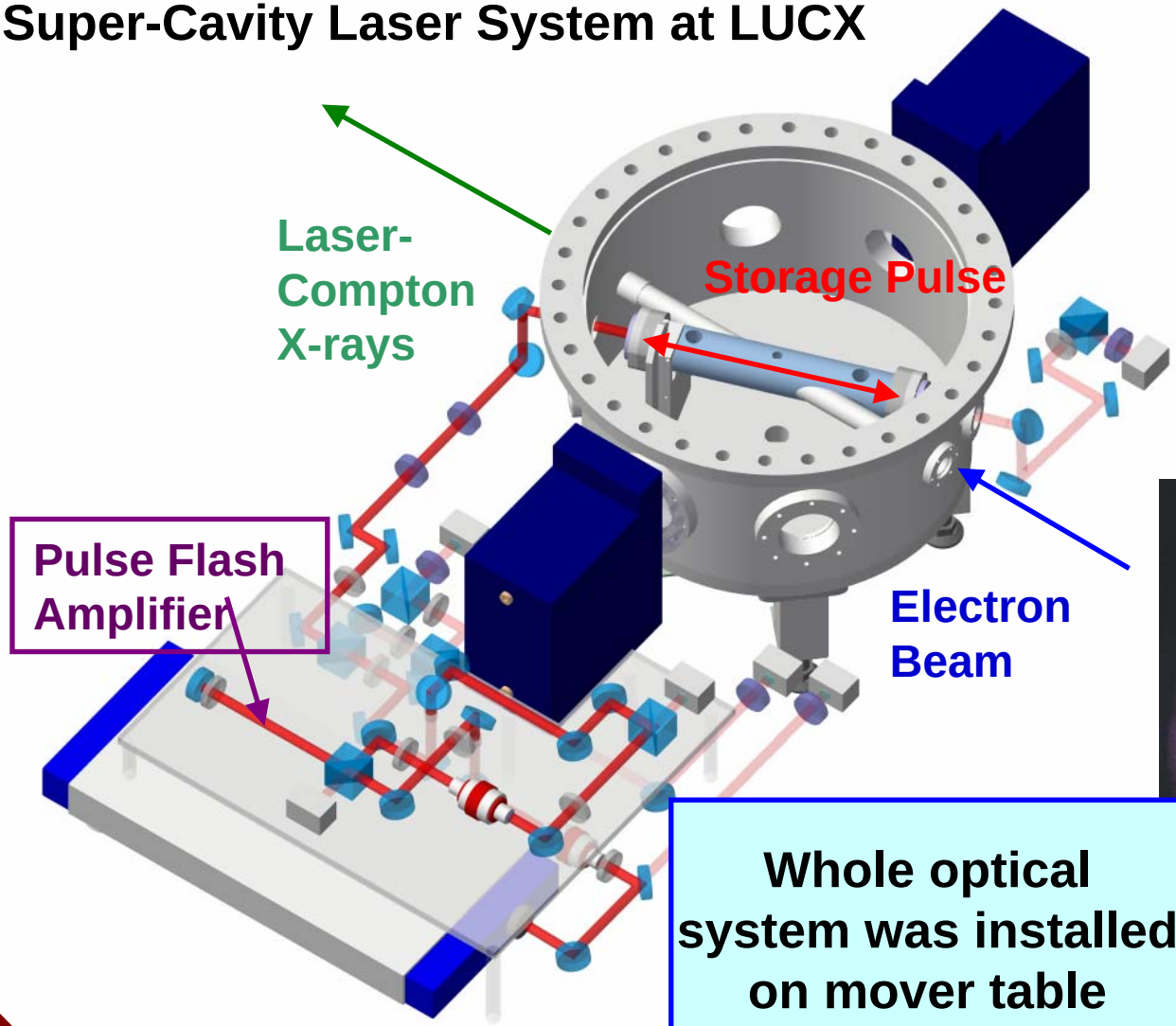


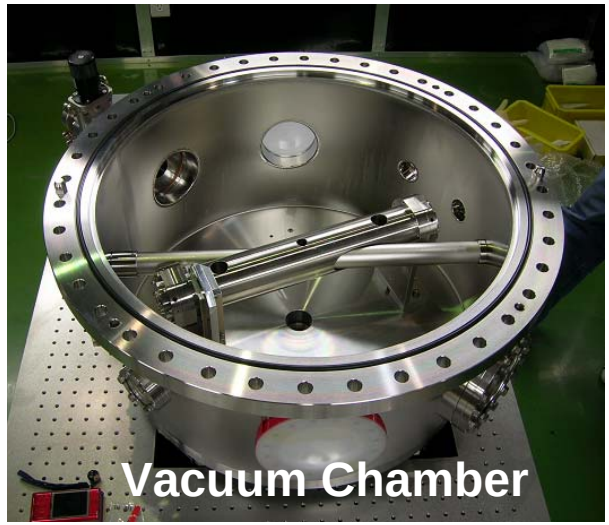


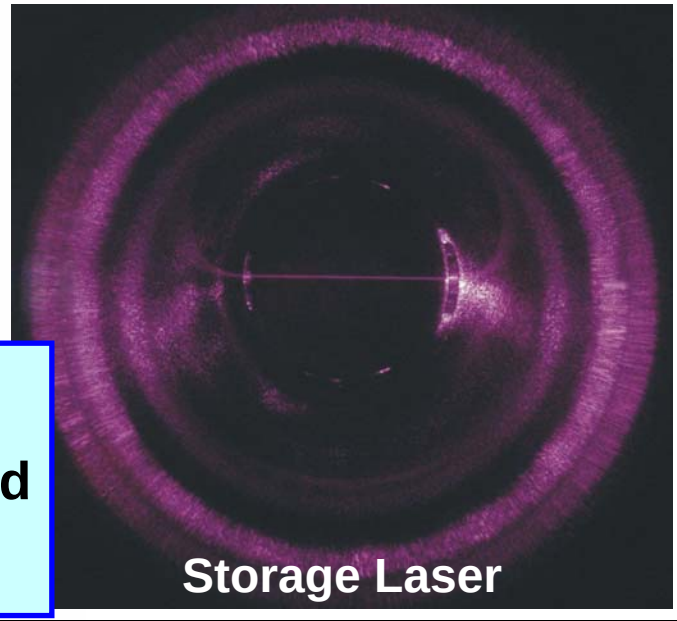


Super-Cavity System at LUCX

Super-Cavity Laser System at LUCX



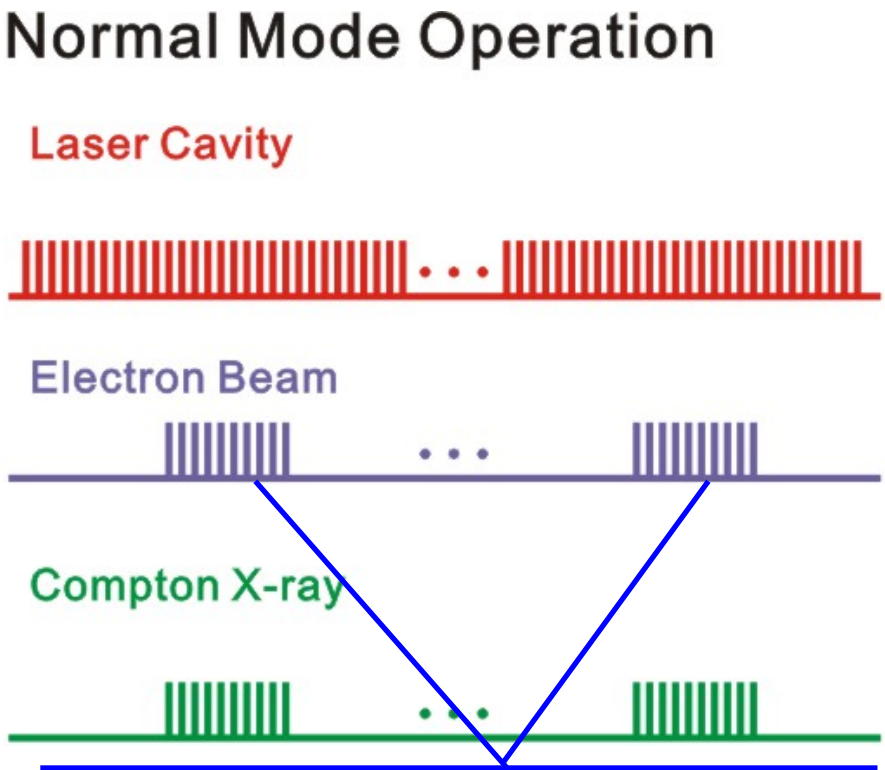


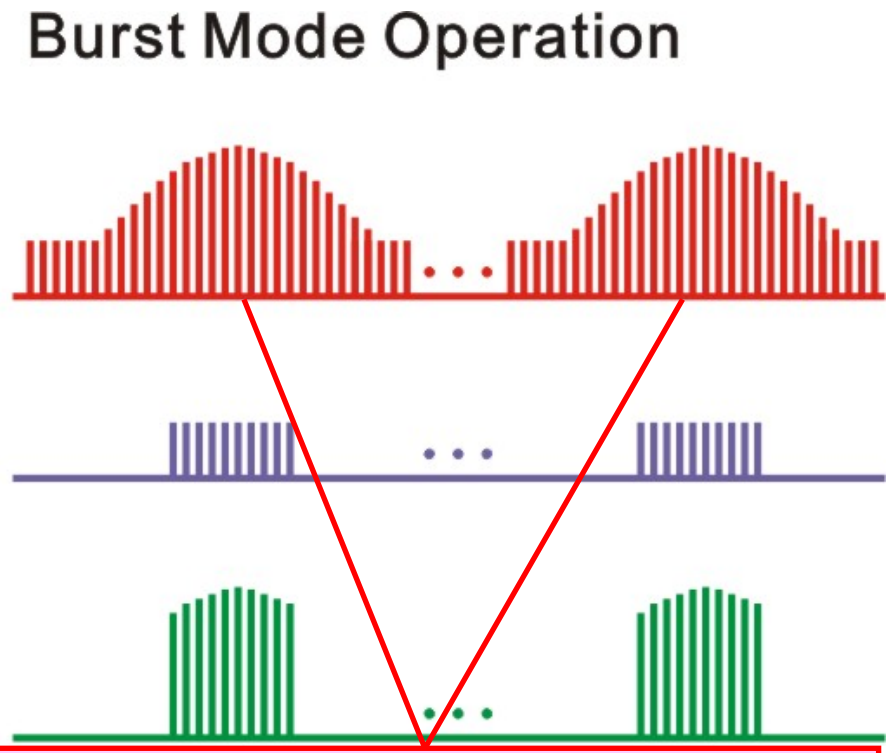


Whole optical system was installed on mover table

Introduction of “Burst Mode”

“Burst Mode” Super-Cavity for Multi-Bunch Electron Beam



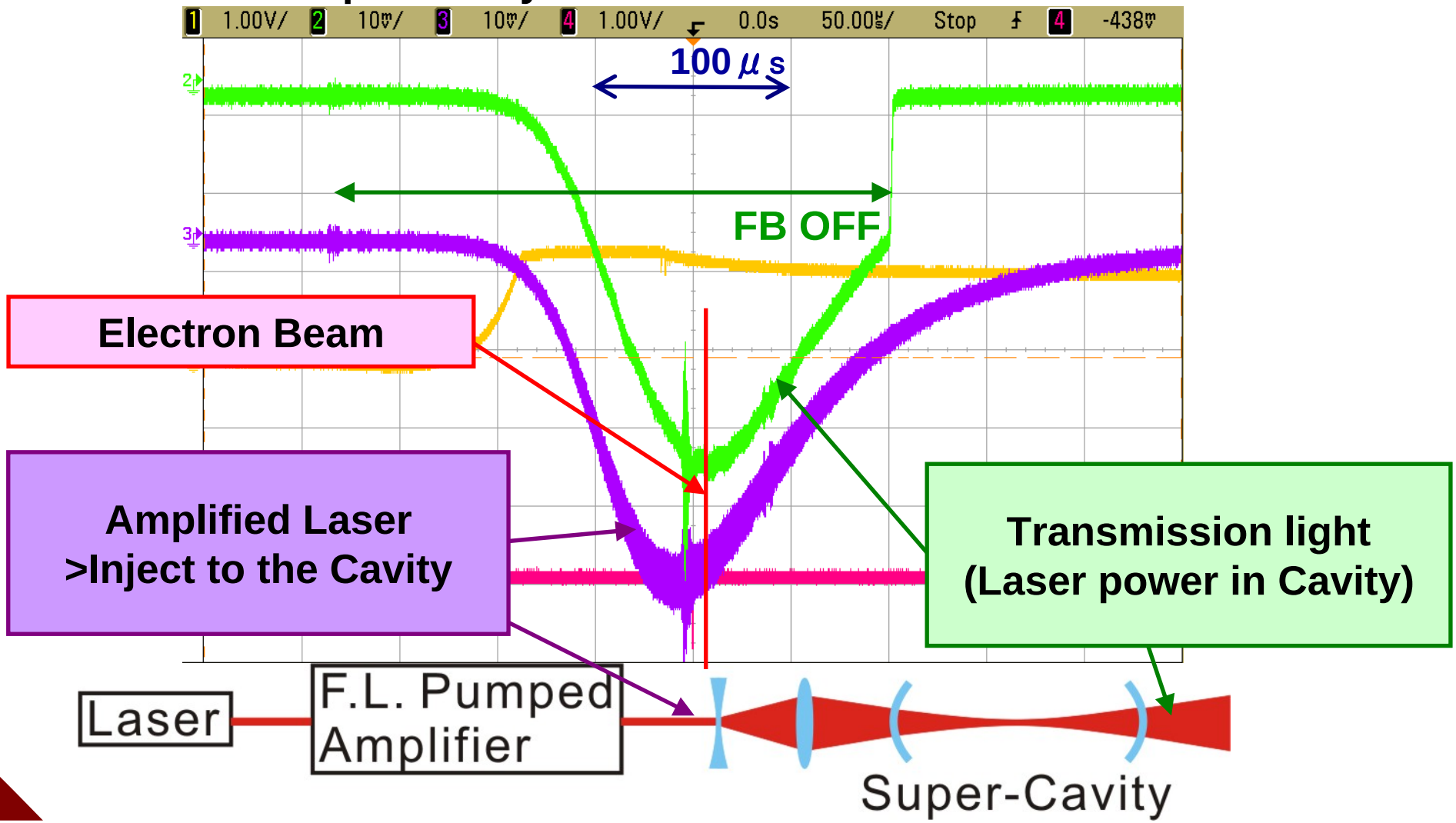


LUCX accelerator produces 100bunch/train macro-bunch in 280nsec (2.8ns bunch space)

<Burst mode>
Stacking the pulse-flash amplified pulses in an optical cavity
>high power pulse can produce in interaction timing

Burst Mode Experiment

“Burst Mode” Super-Cavity for Multi-Bunch Electron Beam



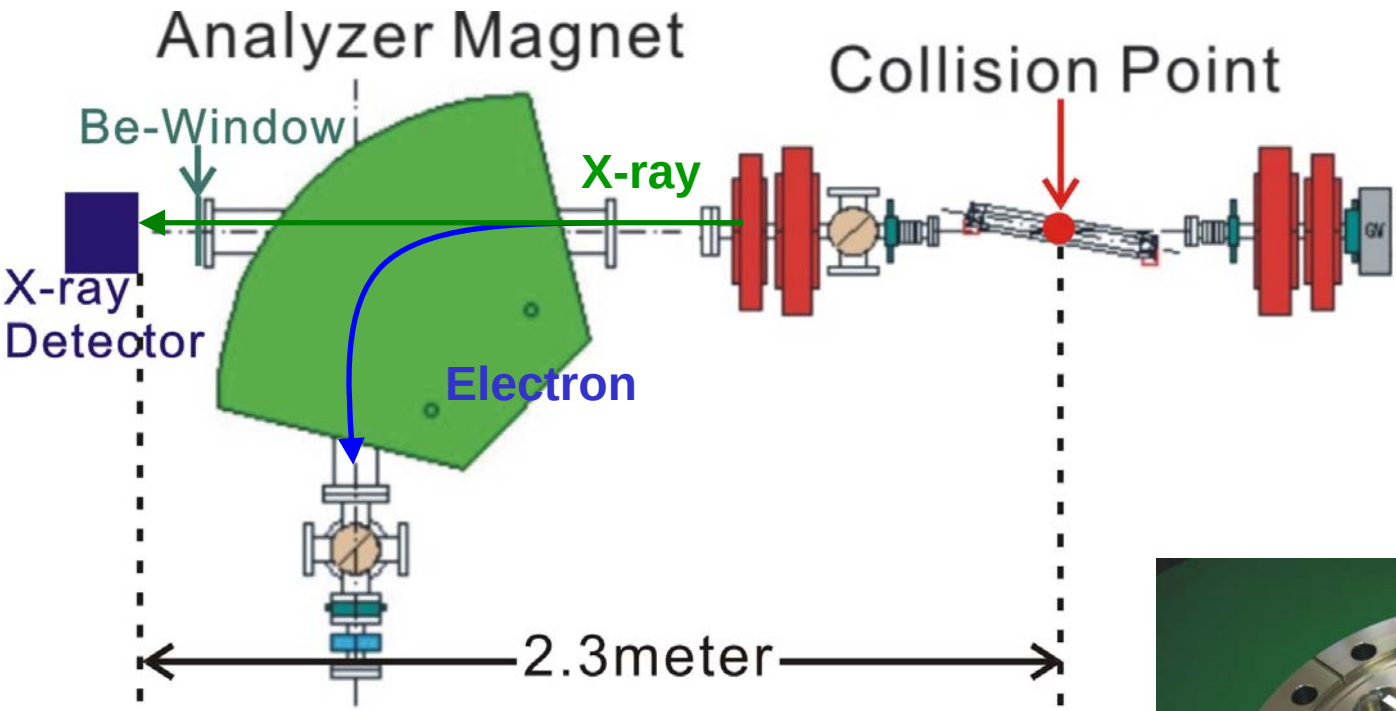
Particle Specification at Collision Point

Laser and Electron Beam Specification at the Collision Point

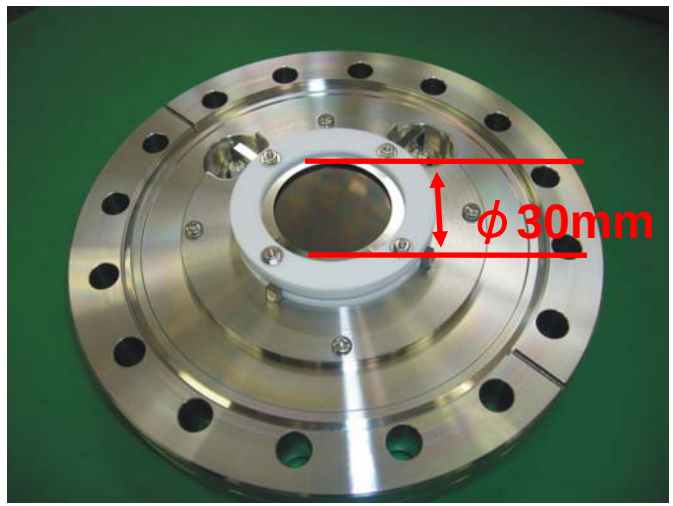
Electron Beam		Colliding Angle	20deg	Laser Pulse	
Energy	Energy Spread	Energy Difference	Wavelength	Pulse Rep.	Amp. Gain
32-44MeV	0.13% (rms)	0.5% (rms)	1064nm	357MHz	70
Bunch Charge	Bunch Length	Beam Size (Hol./Ver.)	Finesse	Peak Power	Pulse Energy
0.5nC/Bunch	5psec (rms)	200μm/60μm	878.5	40kW	112μJ
Bunch Spacing	Num. Bunch /Train	RF Repetition	Enhancement	Waist Size	Pulse Duration
2.8nsec (357MHz)	5-100	3.13-12.5Hz	13000	30.3μm (1σ)	7psec (FWHM)

X-ray Detector

Location of X-ray Detector at LUCX

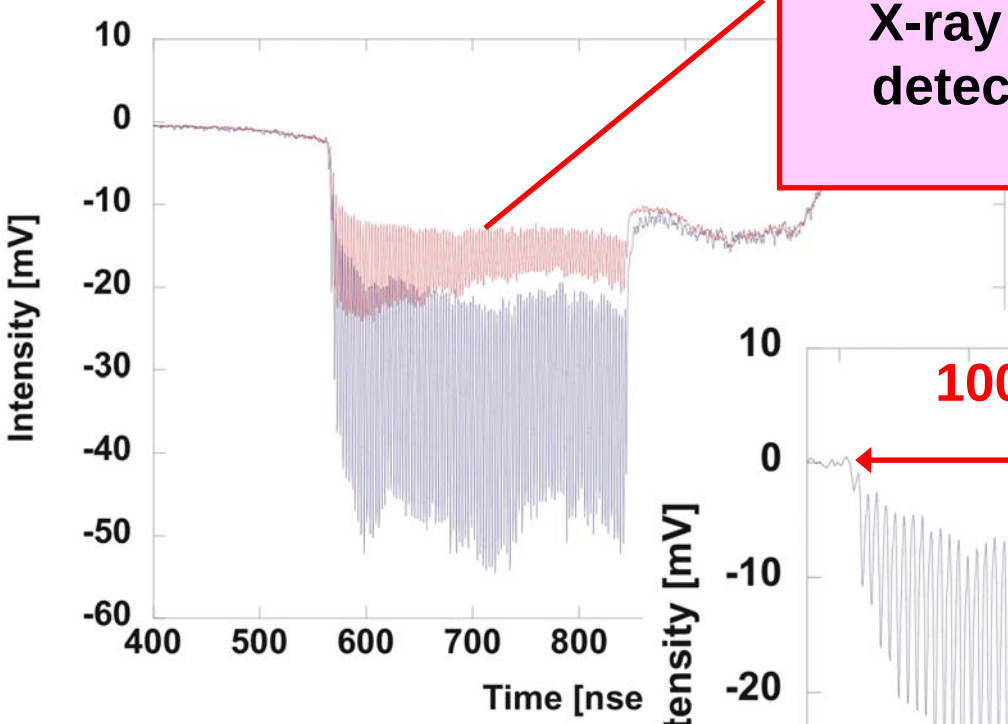


X-ray detector (MCP : Hamamatsu F2224) was located 2.3m down stream from the interaction point.

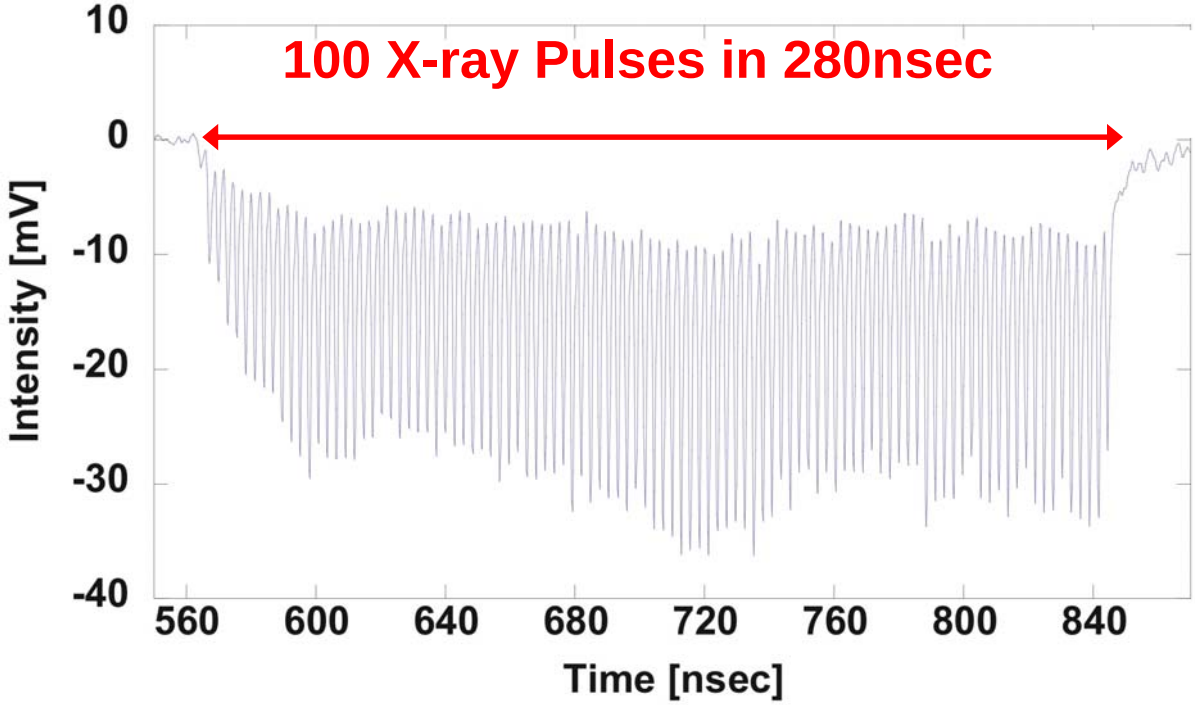


MCP Waveforms

Waveform from Micro-Channel Plate



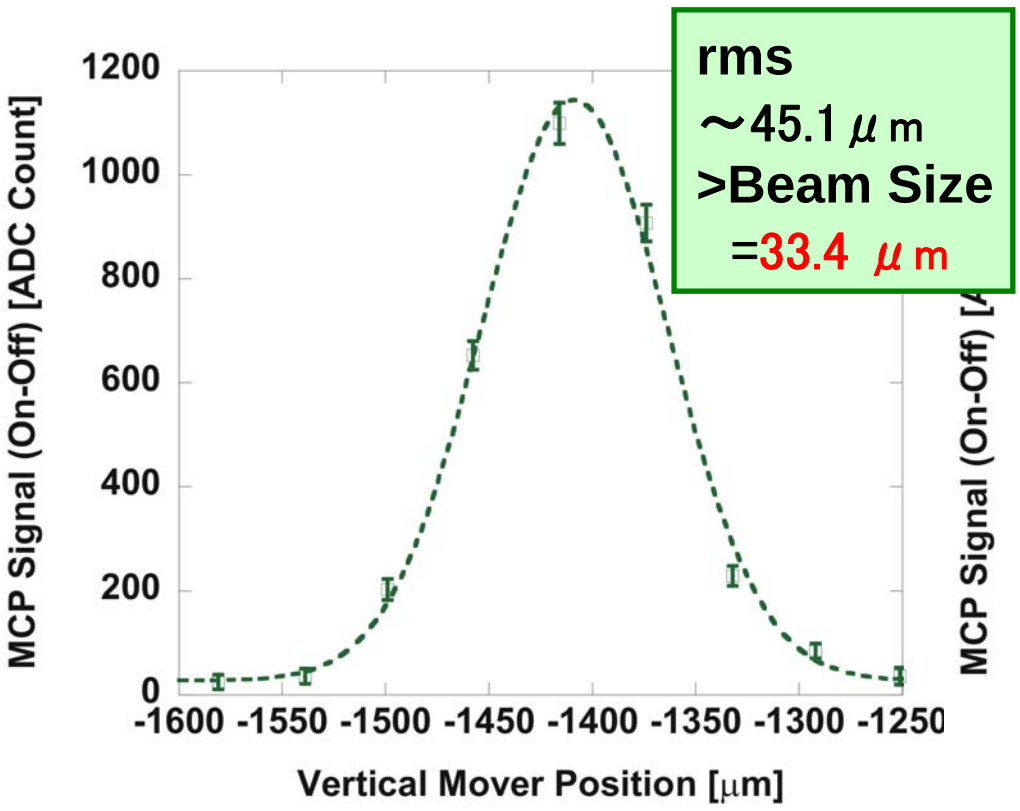
X-ray signal can be detected with laser on/off.



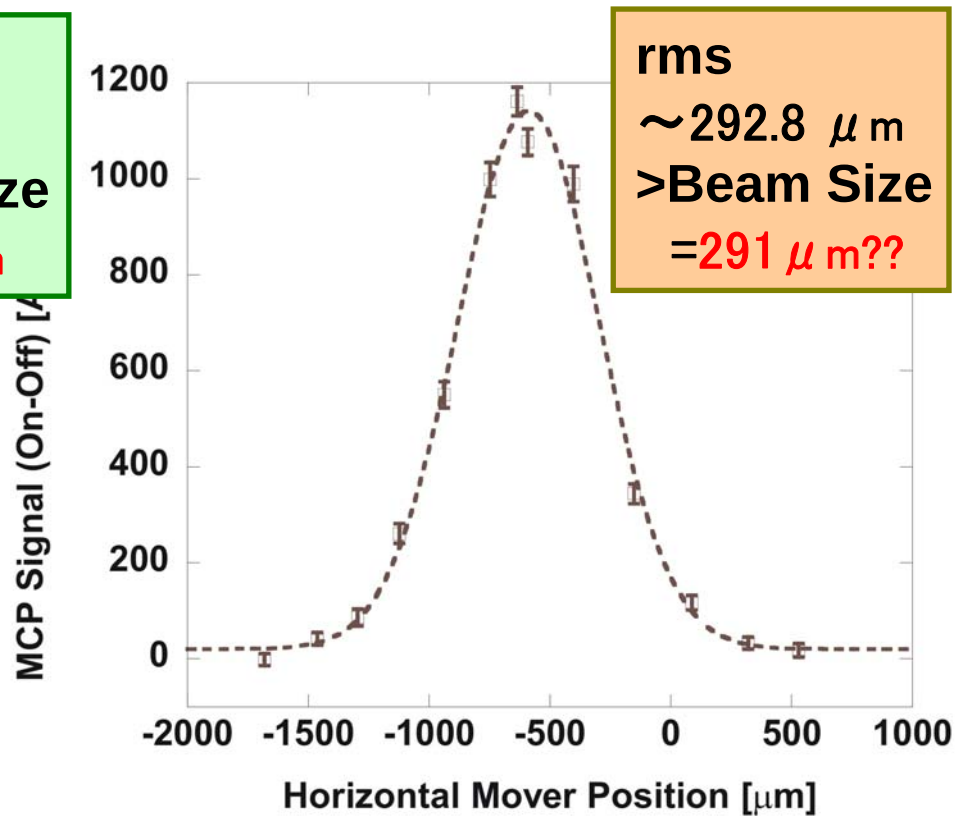
Laser Position Scan

Macro-bunch Profile Measurement

Laserwire (Mover) Position Scan (Vertical and Horizontal)



Mover Position (Vertical) Scan

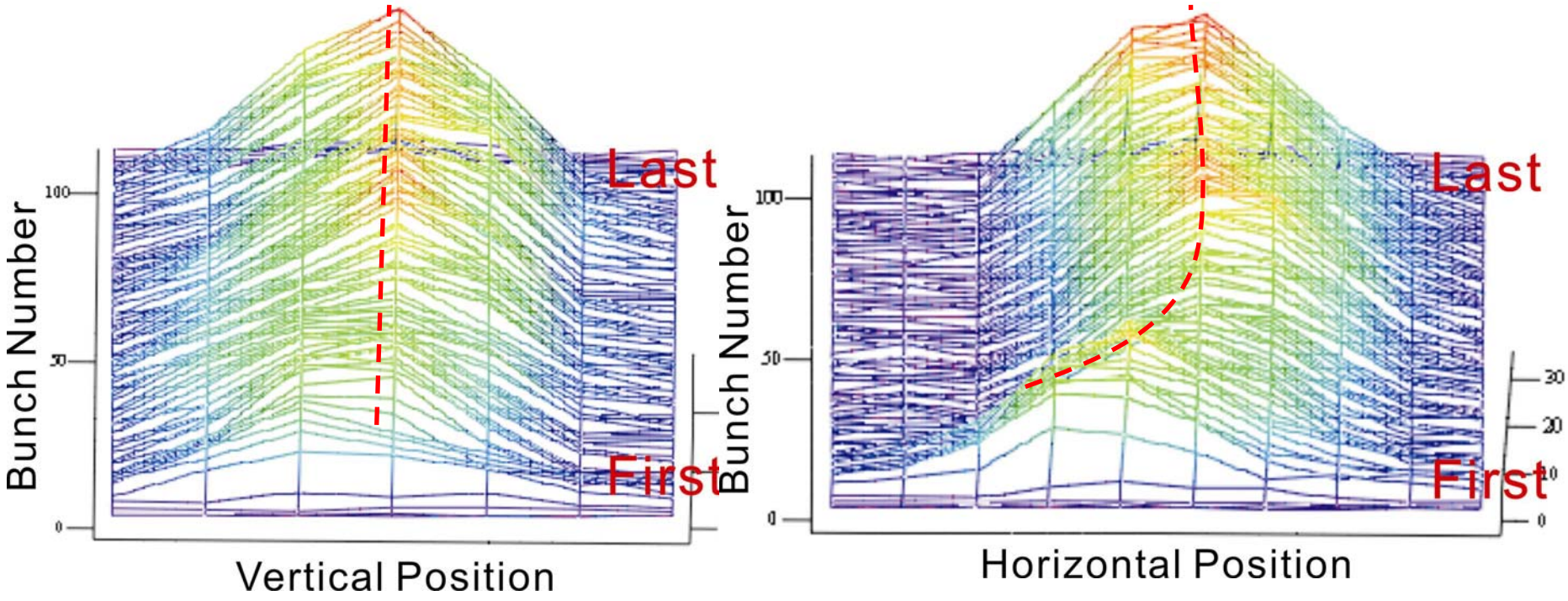


Mover Position (Horizontal) Scan

Bunch-by-Bunch Profile Measurement

Bunch-by-Bunch Profile Measurement

Scanning the mover table position



Bunch-by-Bunch Profile Measurement

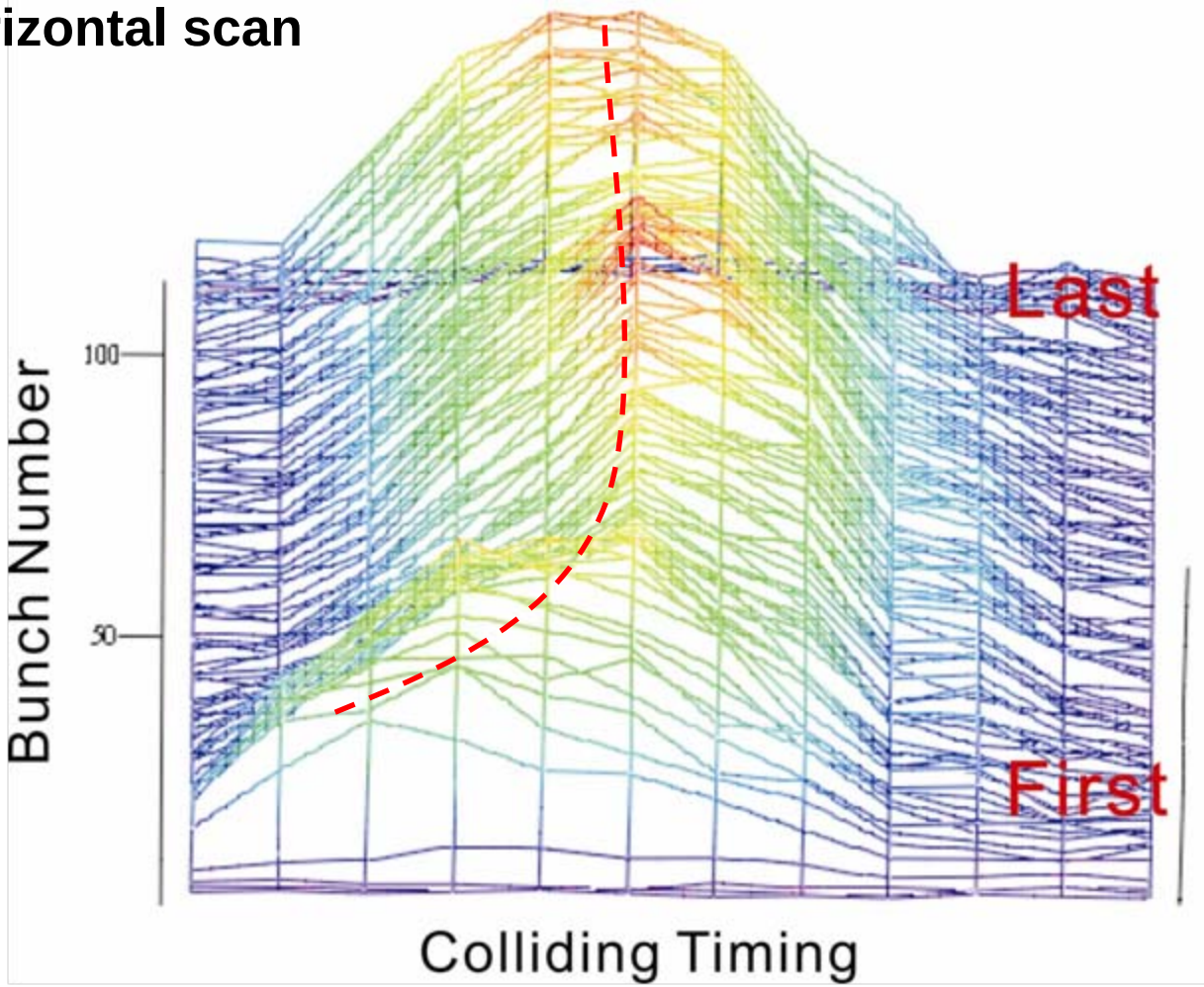
Pulse-by-Pulse Collision Timing Scan

>same behavior with horizontal scan

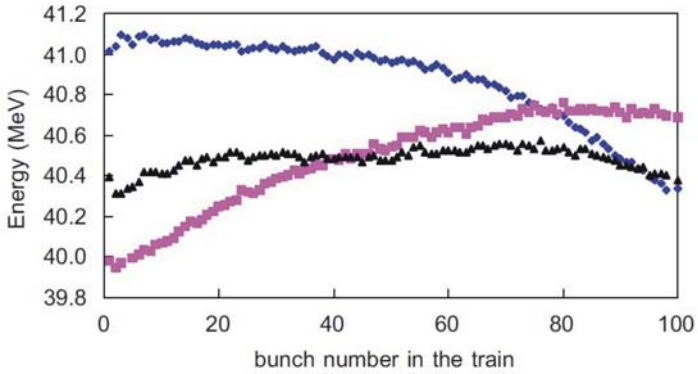
The timing shift and horizontal position shift is coupled as:

$$\Delta h = \left(\beta c \Delta t + \cos\theta\right)\sin\theta$$

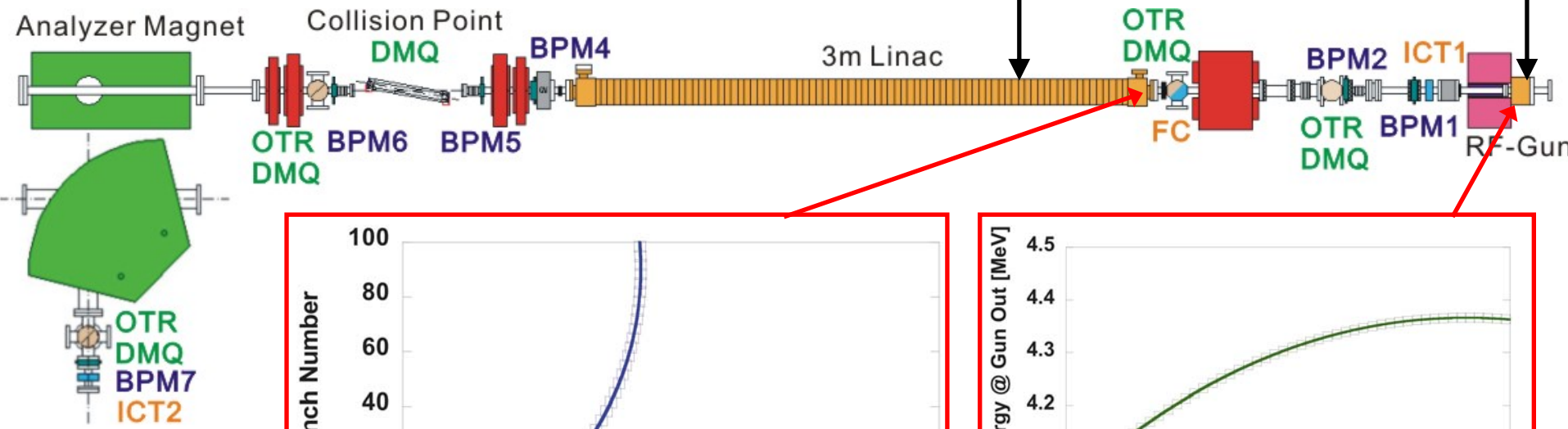
This was originally caused by timing shift in calculation.



Velocity Dispersion at LUCX Accelerator



RF Power Source

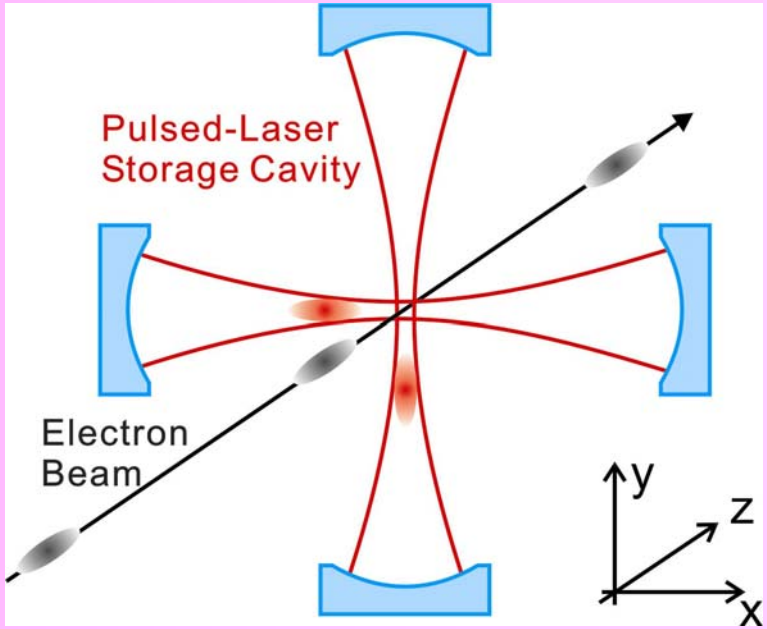


Conclusions

We demonstrated a 3-dimensional profile monitor
using pulse storage optical cavity.
The transverse and longitudinal profile can be measured
for each bunches in multi-bunch electron beam.
Further more, the bunch spacing narrowing was observed
in the LUCX multi-bunch electron beam due to the velocity dispersion.

For profile monitor, the setup
in right figure (90deg collision) is better.

Also, this monitor has feasibility for
measuring an ultra-fast bunch length
by stacking an ultra-fast pulses
in the optical cavity.



Thank you

Slides for Questions

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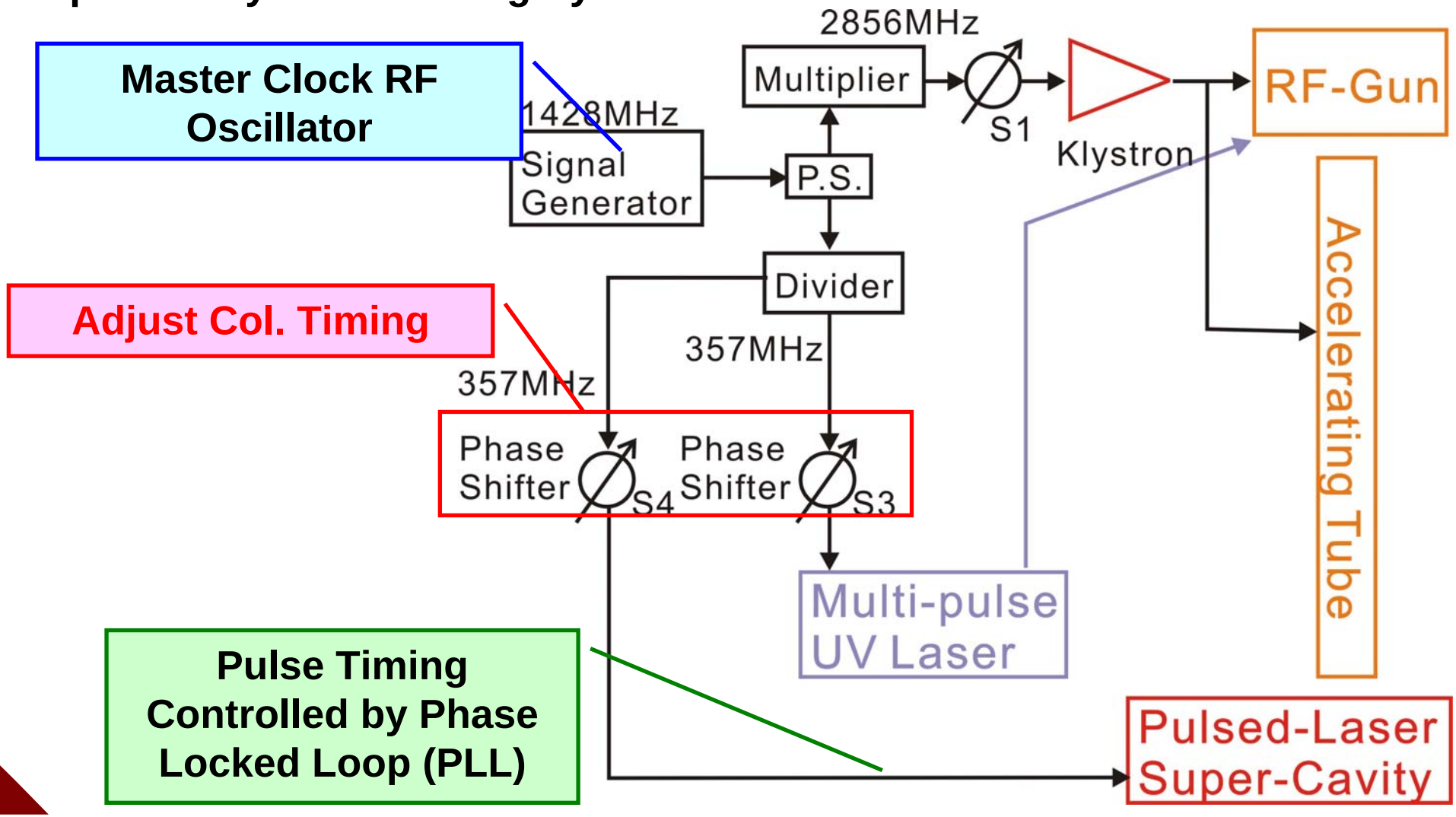
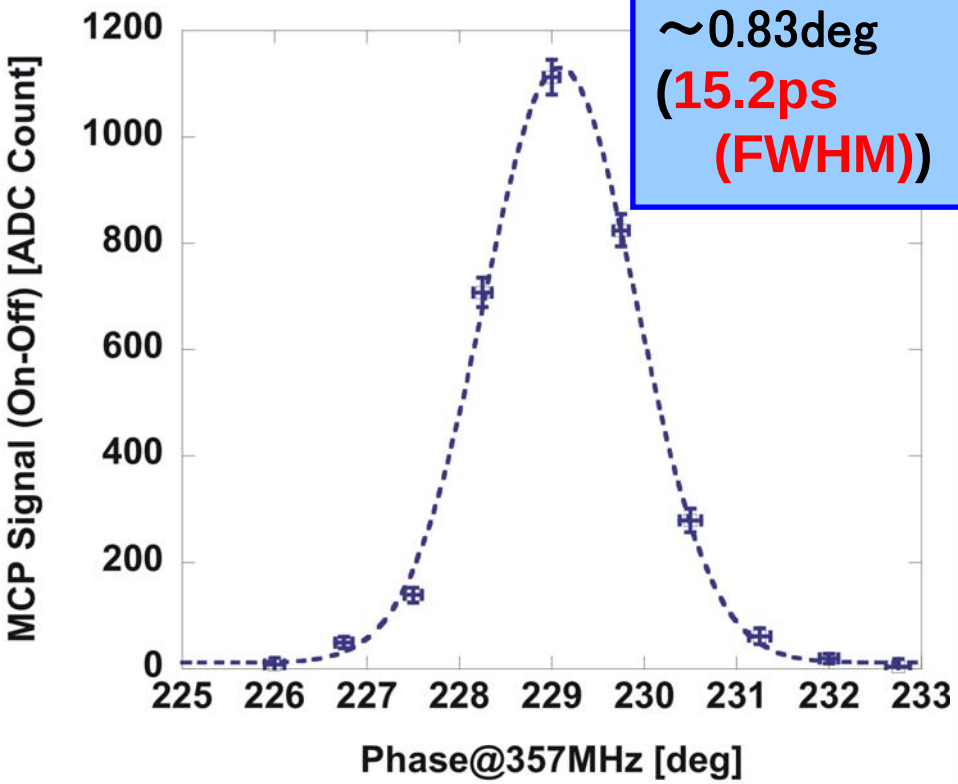
Super-Cavity Laser Timing System



Slides for Questions

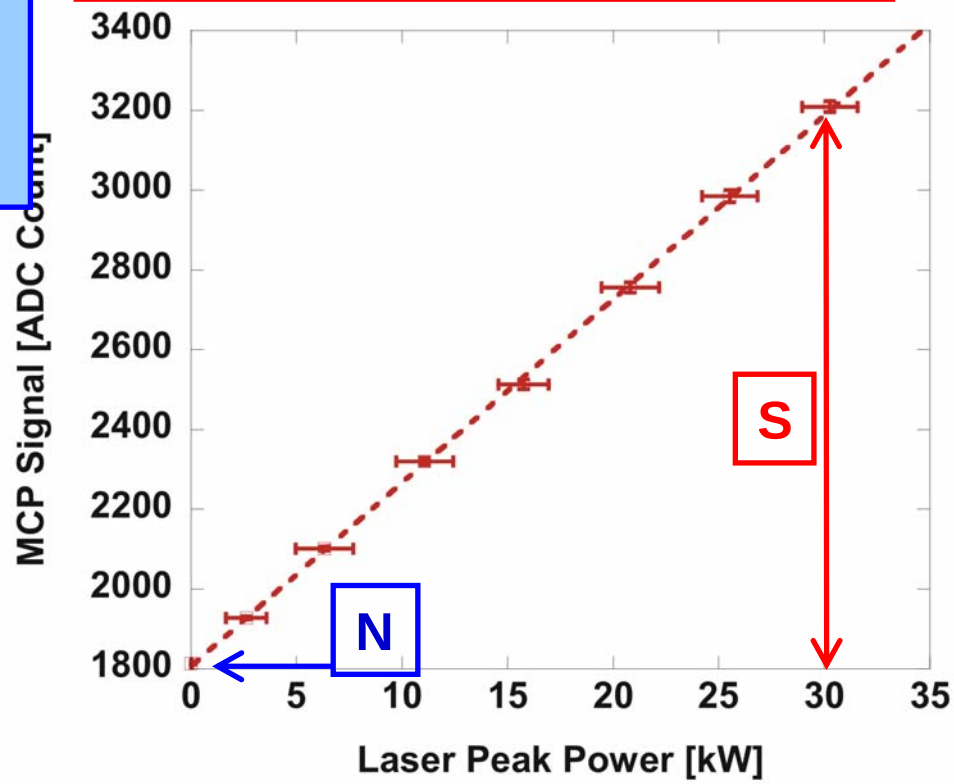
Timing Scan and Laser Power Correlation by MCP with Charged ADC

rms
～0.83deg
(15.2ps
(FWHM))



Timing Scan

S/N～1/1.3　S : X-ray Intensity
N : ADC count at Laser OFF



Laser Power Correlation Plot

Slides for Questions

Coupling of Horizontal Shift and Timing Shift

Timing Scan in Each Horizontal Position (-0.3mm/0mm/+0.3mm)