

# Generating short x-ray pulses at synchrotron light sources using pulsed magnet kickers

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NSLS II

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# Shorter pulse generation methods

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- 1. Vary the longitudinal parameters:

Voltage or phase modulation:

APS: 2 times shorter

lower momentum compaction factor

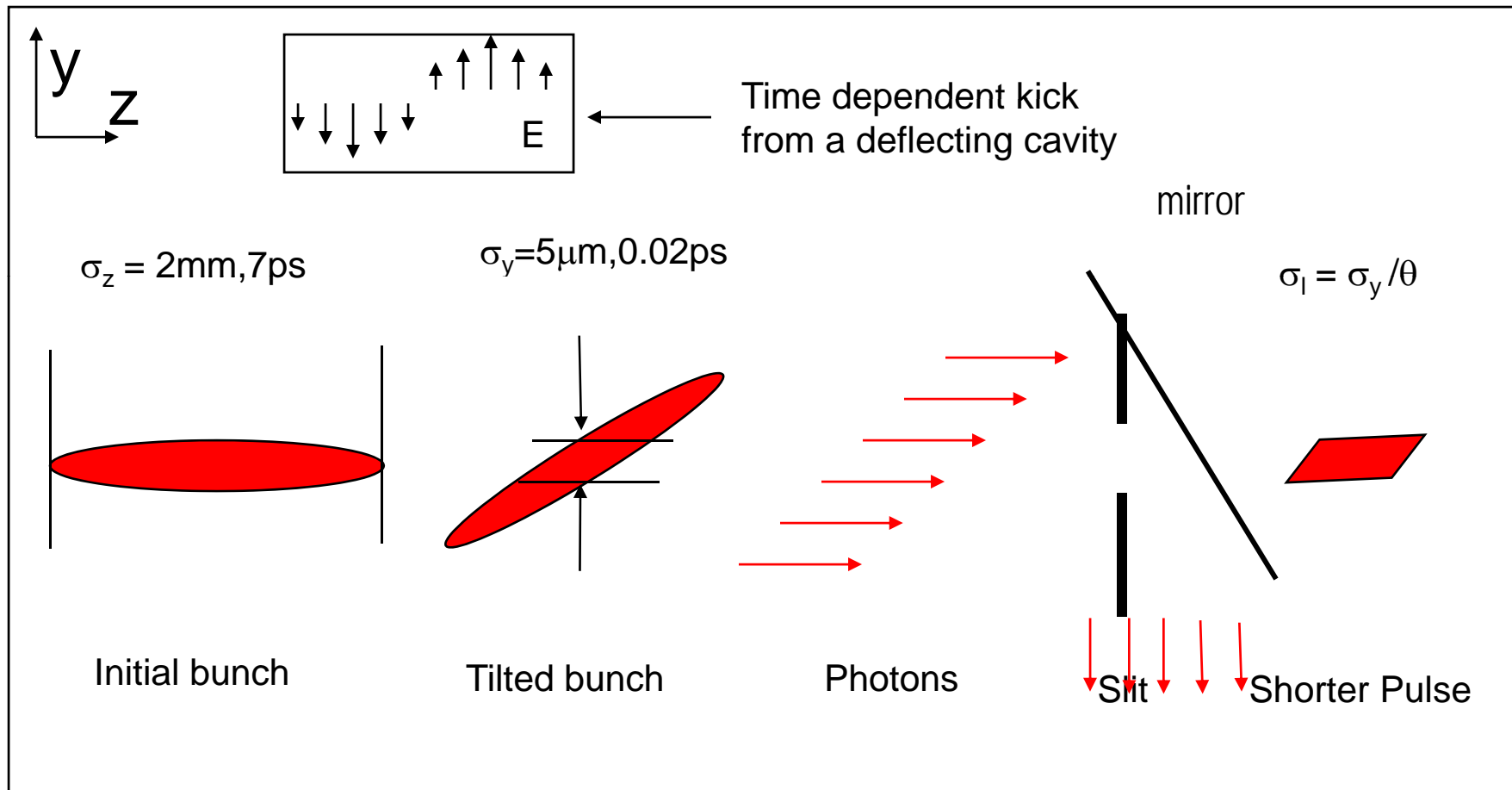
BESSY II: 3ps, 100  $\mu$ A (nominal: 15 ps, 250 mA)

- 2. Laser slicing, Thomson scattering

BESSY II,ALS,SLS: ~100 fs, ~1 kHz,  $10^3$ photons/pulse

- 3. Rf deflection cavity, vertical kick method

# Tilt the Bunch to Get Shorter Pulses



# Deflecting Cavity vs Synchrotron coupling

$$A(z) \sin(\nu_x \theta + \psi)$$

Cavity → Betatron Osci. →  
Kick

$$A \sin(\nu_x \theta + \psi(z))$$

Magnet → Synchrotron  
Kick → Coupling



$$\nu_y = \nu_0 + C_y \delta + \dots \quad \delta = \frac{\Delta P}{P}$$

$$y = y_0 \sin(\nu_{y,0} \theta + C_y \int_1^2 \delta d\theta + \Psi(s)) + \sqrt{2\beta J} \sin(\nu_{y,0} \theta + C_y \int_1^2 \delta d\theta + \Psi_0)$$

$$\begin{cases} \delta \propto -\Delta z \\ \Delta z \propto \delta \end{cases} \quad \int_1^2 \delta d\theta = \Delta z_2 - \Delta z_1 \xrightarrow{1/2T_s} -2\Delta z_1$$

$$\langle y(\delta, \Psi_0) \rangle (\Delta z) \propto \sin(\nu_{y,0} \theta - \frac{2C_y \omega}{h\alpha_c \nu_c} \Delta z + \Psi_s)$$

Kick and  
Wait for  
Half synchrotron  
Period.....

# Movie showing the side view of the bunch motion

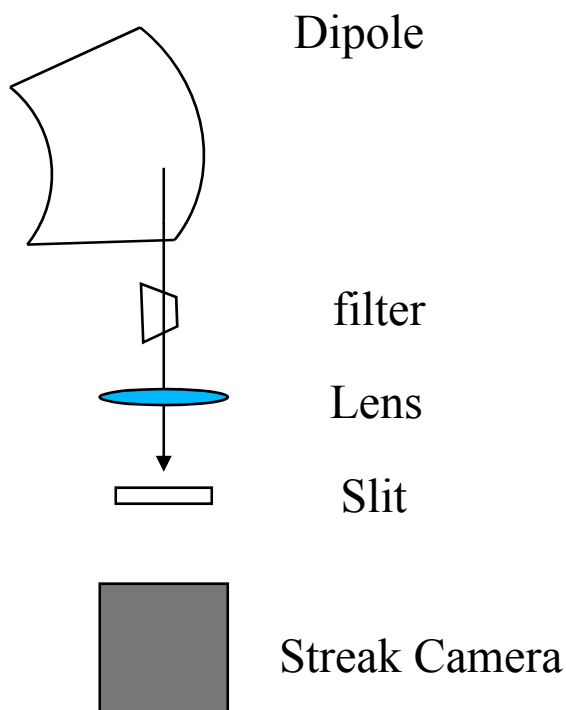
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- Initial condition:
- Kick strength  
0.2 mr

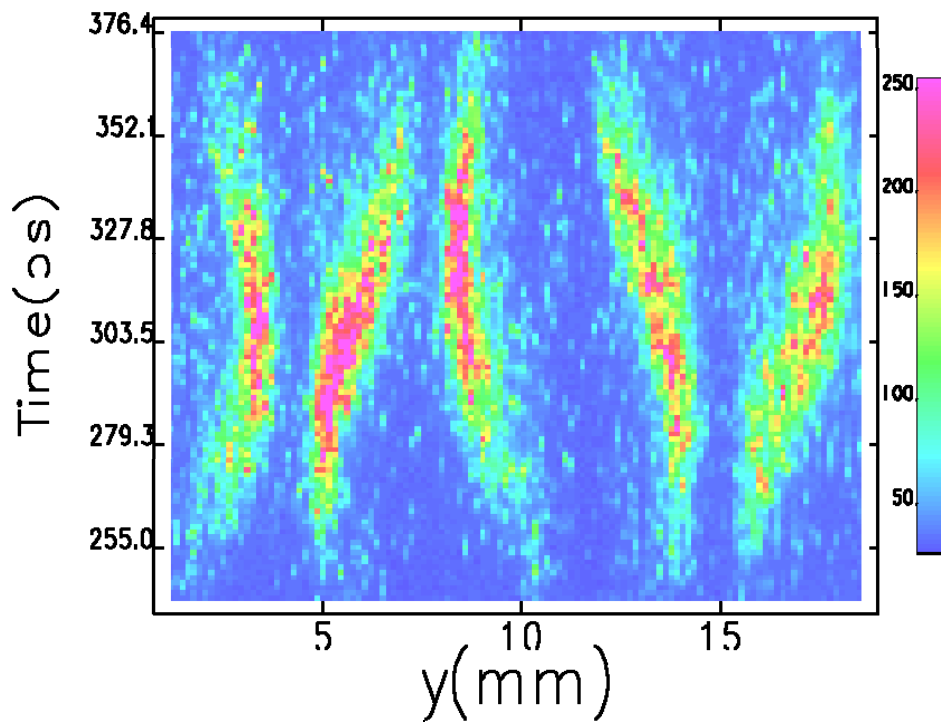
# Experiment Setup for Streak Camera Imaging

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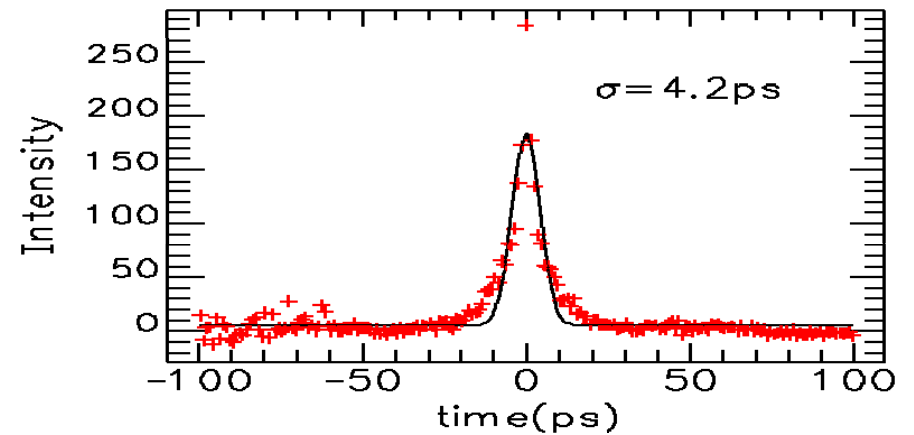
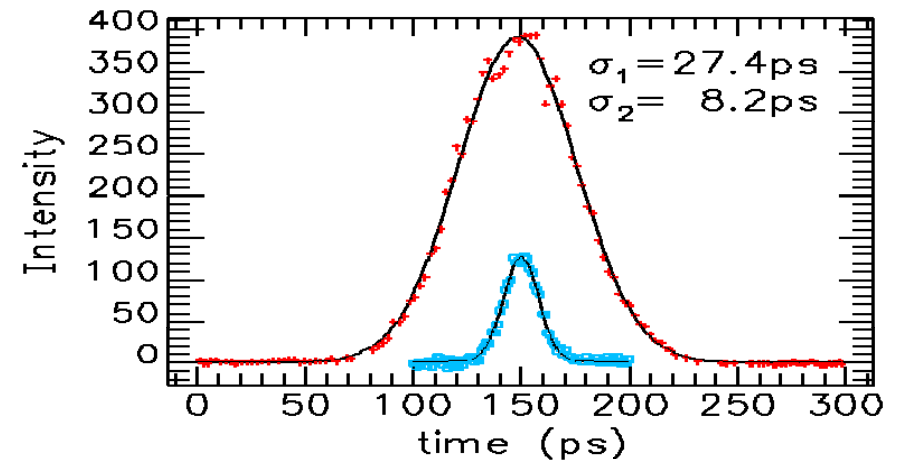
- $C_y$  was lowered to 4,  $C_x=6$  was unchanged.
- $I=1.3$  mA, kick  $\theta=0.12$  mr, kick  $f = 2$  Hz
- Streak camera resolution: Y 0.43 ps(0.13mm), Z 2.2 ps.
- Filter: 10x550 nm
- The effective slit width was 100  $\mu\text{m}$ .

# Streak Camera Measurement Results

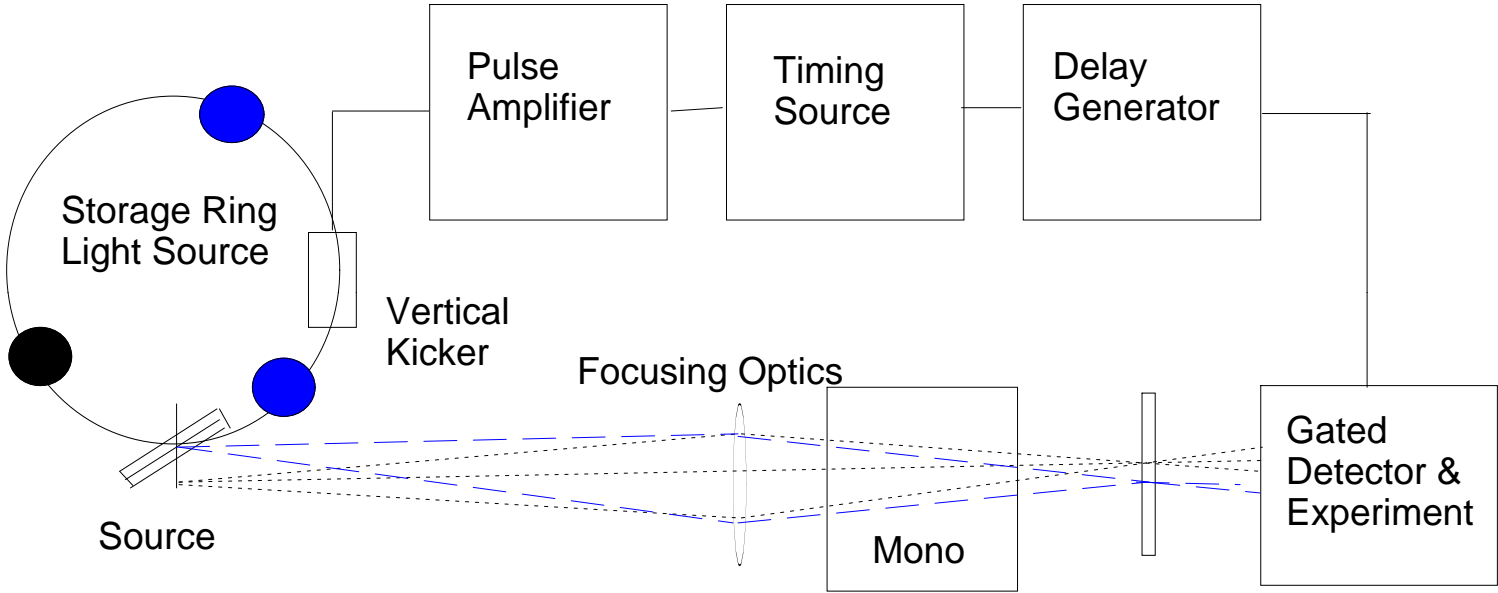


Pixel size: 0.036mm\*1.2ps

Turn 83-87



# Shorter Pulse Generation Scheme



## Comparison of different methods for NSLS II

	Minimum pulse length (ps)	Rep. rate	Integrated Flux ( $\times$ original)	Dedicated?	Synchronized?
Lower alpha-c	~0.7	500 MHz	$4 \times 10^{-4}$	Yes	No
Laser slicing*	0.1	~1 kHz	$1.5 \times 10^{-8}$	No	Yes
Crab cavity**	0.38	500 MHz	~1	No	No
Vertical kick***	$\rightarrow 0.32$	~1 kHz	$1 \times 10^{-5}$	Yes	No

\*Laser: 1kHz, 100 fs duration, 5~10 mJ, 24 bunches

\*\* crab cavity: 4.5 GHz, 4 MV

\*\*\*kicker: 100 ns duration, 24 bunches

# Summary

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- Tilt can be generated by a pulsed magnet kick
- Experimental results at the APS
- Comparison of different methods for the NSLS II