ICFA Workshop on Future Light Sources, Hamburg, May 15-19th, 2006

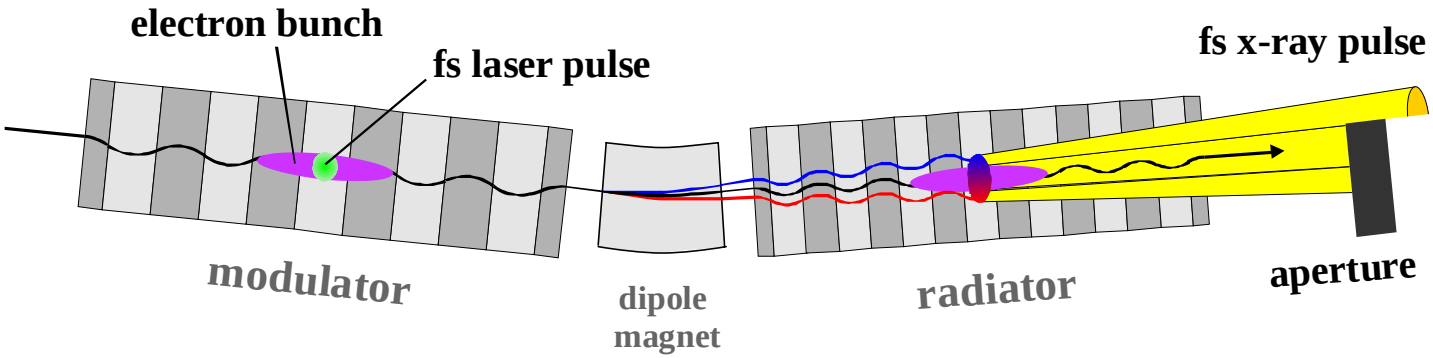
Timing Issues for the BESSY Femtoslicing Source

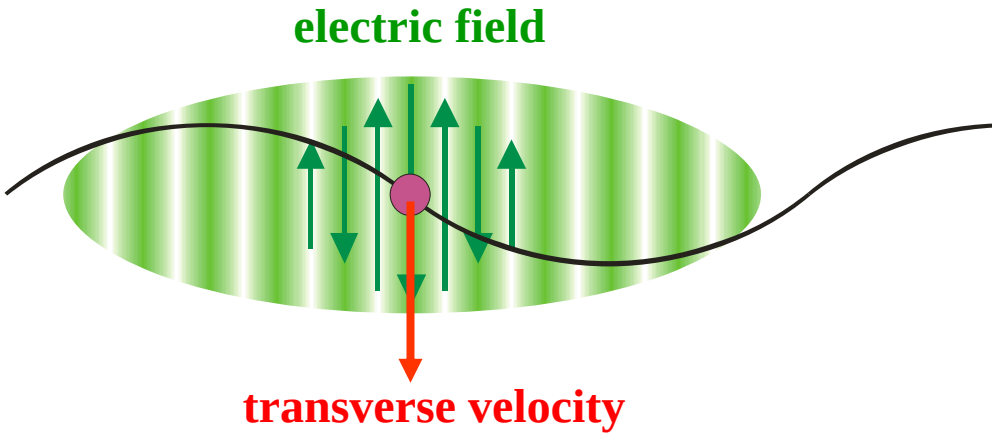
Shaukat Khan, University of Hamburg
R. Mitzner, University of Münster
T. Quast, BESSY/Berlin

- laser-electron timing
ps and ns level

- pump-probe timing
fs level

Femtosecond laser slicing [1]

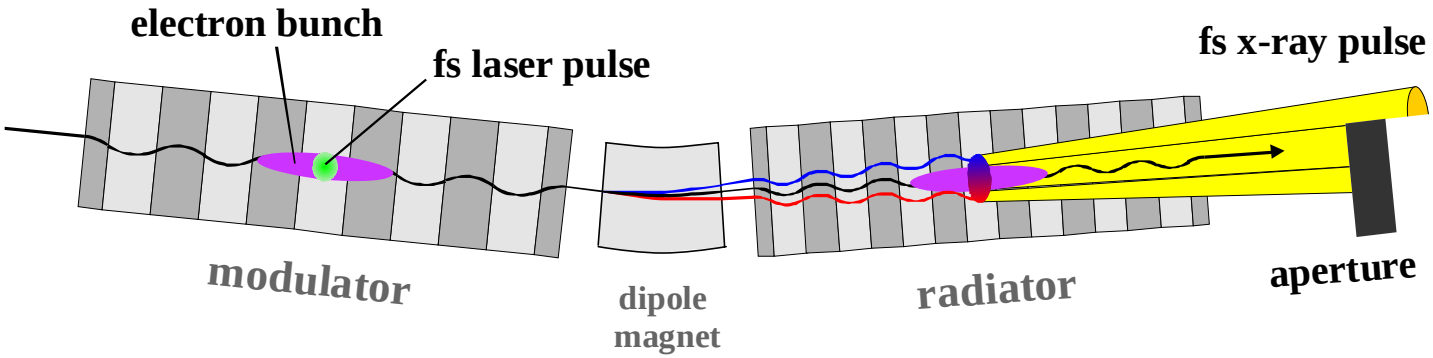


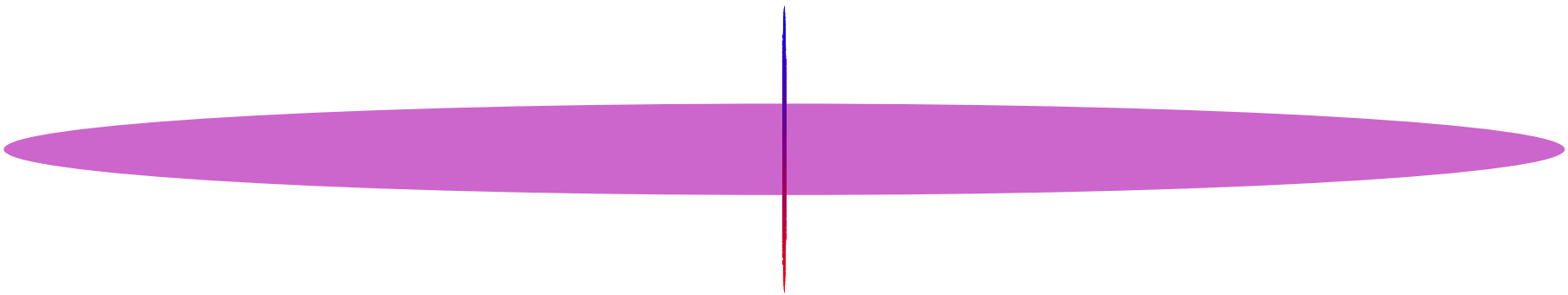


$$\lambda_{laser} = \frac{\lambda_{undulator}}{2(E/m)^2} \cdot (1 + K^2/2)$$

[1] A. A. Zholents, M. S. Zoloterev, PRL 76 (1996), 912.

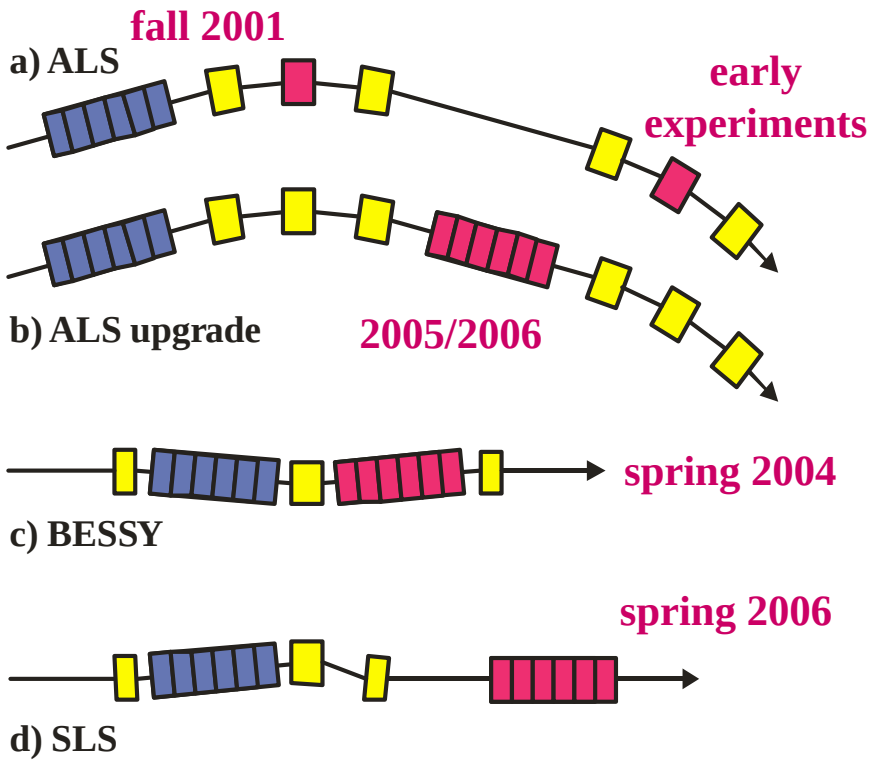
Femtosecond laser slicing [1]



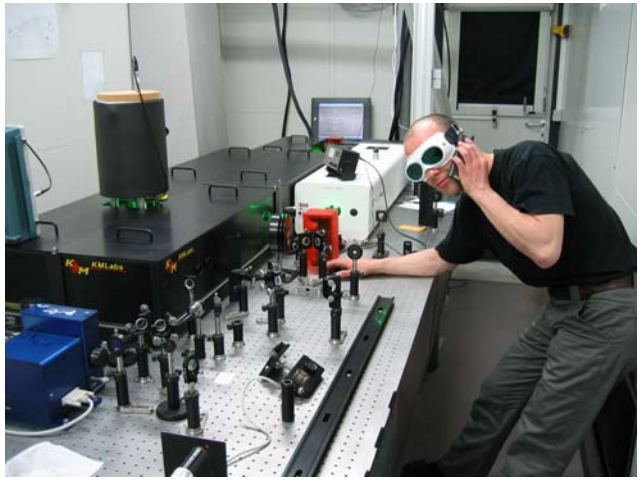


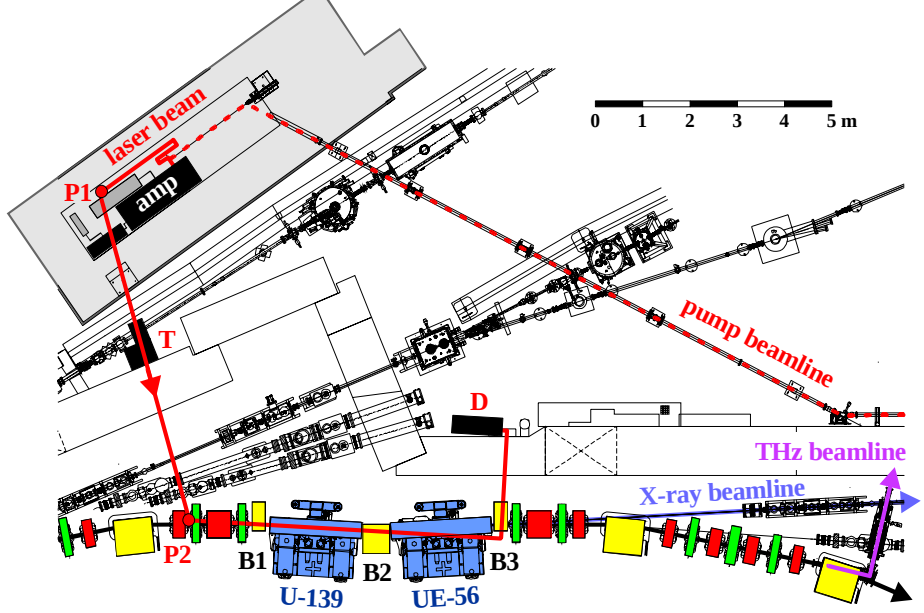
[1] A. A. Zholents, M. S. Zoloterev, PRL 76 (1996), 912.

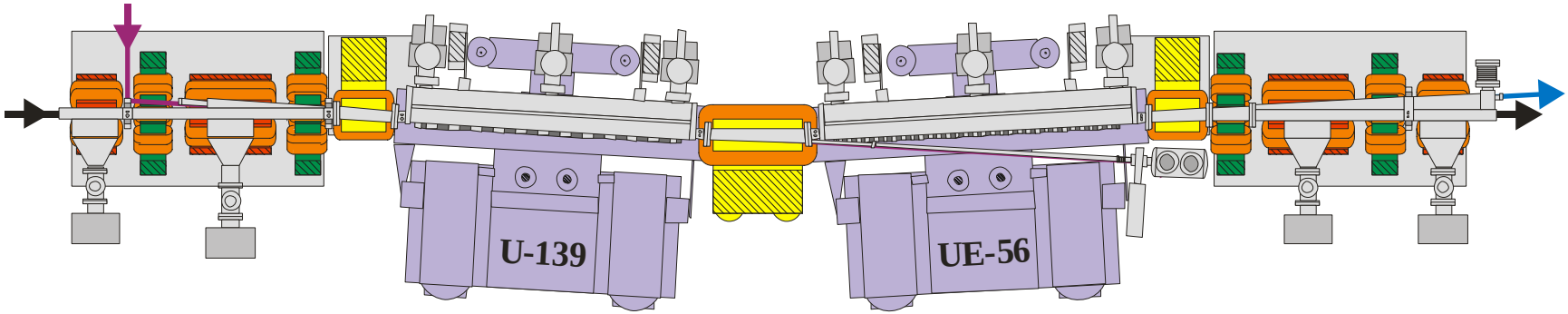
Femtosecond laser slicing worldwide



	ALS(new)	BESSY	SLS
beam energy (GeV)	1.9	1.7	2.4
photon energy (keV)	0.2-10	0.4-1.4	3-8
separation scheme	spatial	angular	angular
pulse length (fs, fwhm)	200	100	100
photons/pulse (0.1% bw)	2000	1000	1000
repetition rate (kHz)	20	1	1
laser pulse energy (mJ)	1.5	2	5



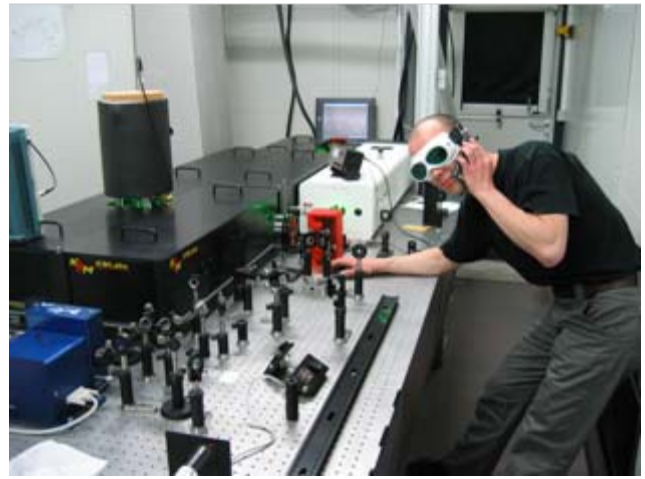

laser beam
amp
P1
T
D
P2
B1
B2
B3
U-139
UE-56
pump beamline
THz beamline
X-ray beamline
0 1 2 3 4 5 m

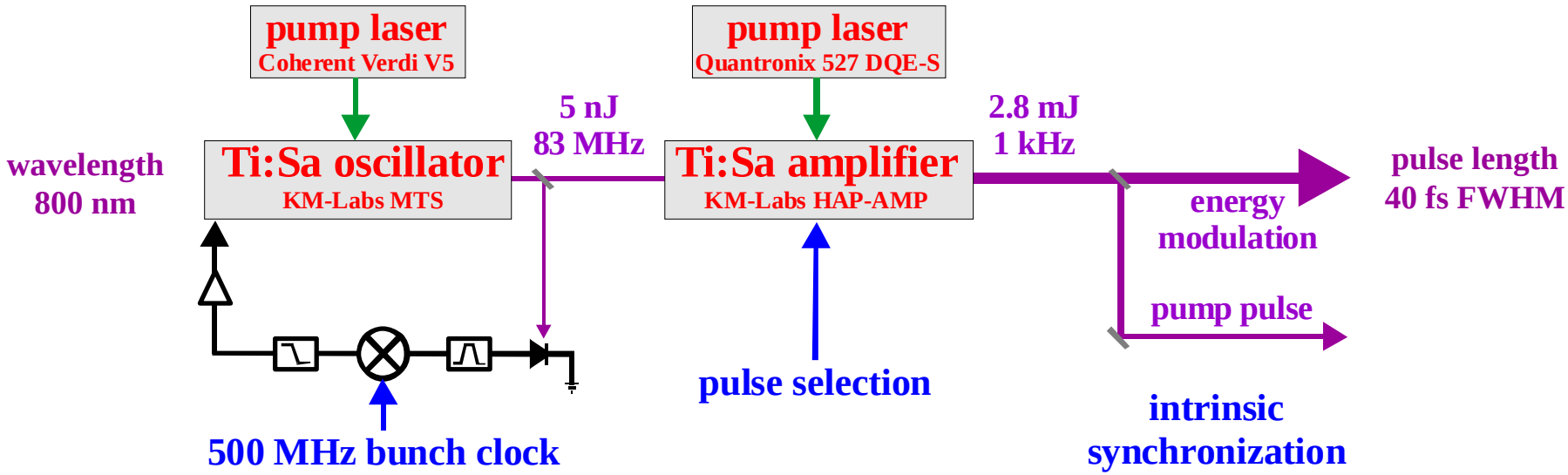

U-139
UE-56

Laser-electron timing

(1) oscillator and storage-ring rf
for 83.3 MHz = 500 MHz / 6

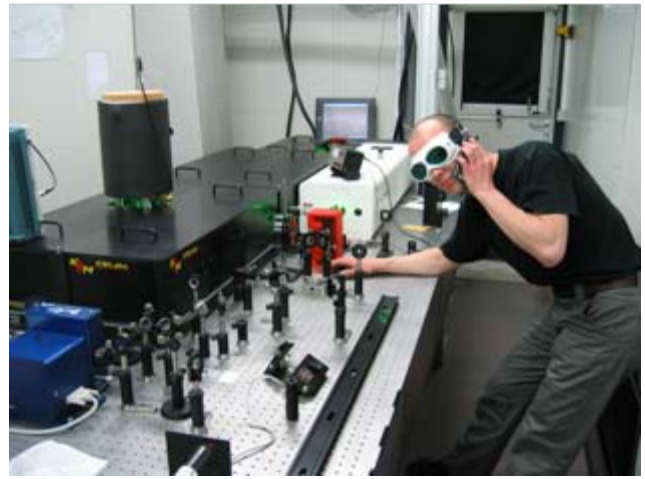
(2) amplifier pulse selection
- pump laser timing
- Pockels cell timing





$$\sin(\omega t+\varphi)\cdot\cos(\omega t)=\frac{1}{2}\{\sin(\varphi)+\sin(2\omega t+\varphi)\}\approx\frac{\varphi}{2}+\ldots$$

Laser-electron timing



(1) oscillator and storage-ring rf
for 83.3 MHz = 500 MHz / 6

(2) amplifier pulse selection
- pump laser timing
- Pockels cell timing

Requirements:
better than longitudinal mode-zero bunch oscillations ~ 3 ps (0.5 deg rf)
for 15 ps rms bunch length ~ 2% electron density change

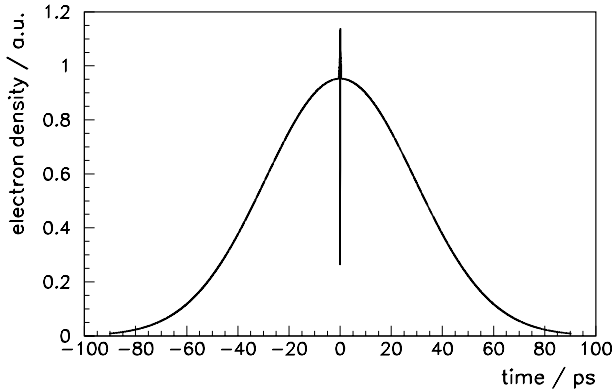
Specified jitter:
less than 250 fs

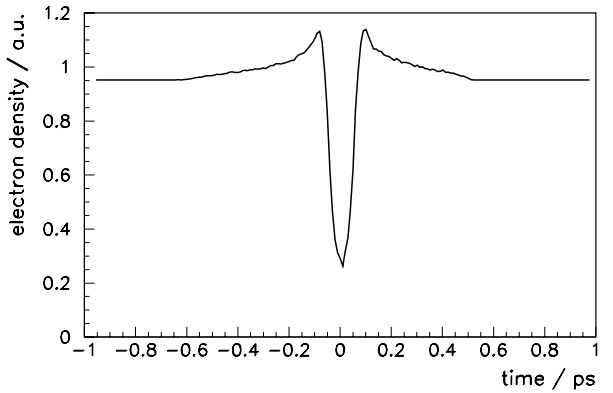
Measured:
less than 1 ps (spectrum analyzer)

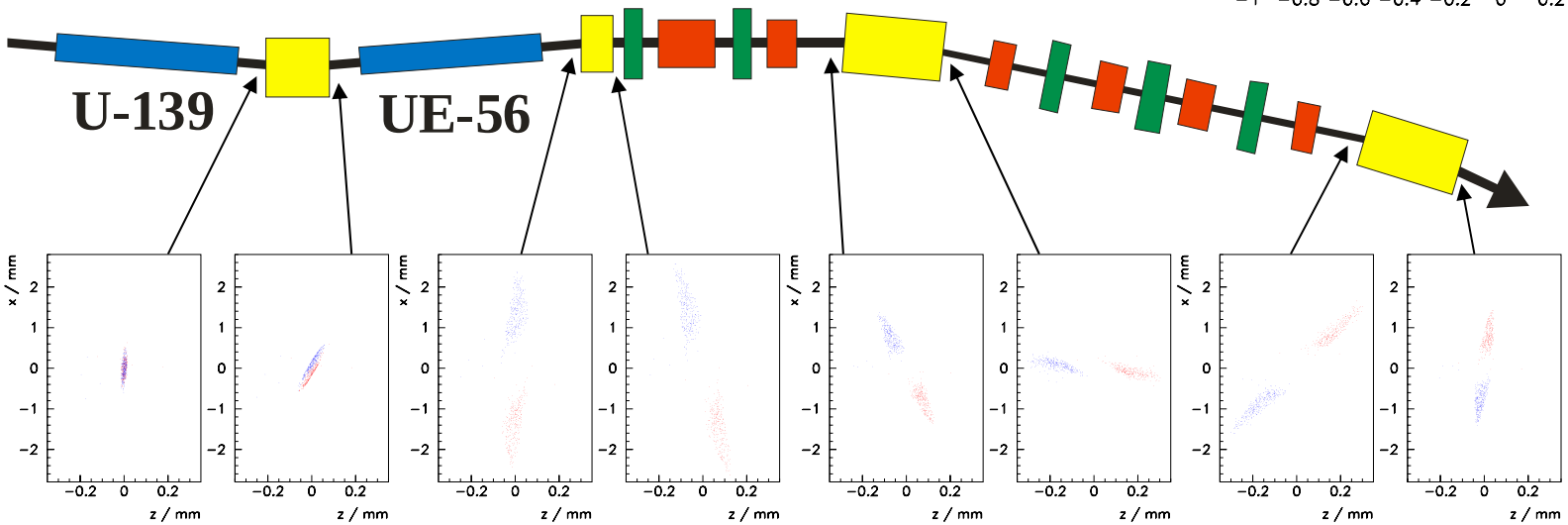
Tuning:
(a) 6-fold ambiguity: trial and error, checked by scope (ns)
(b) two trombones (one manual, one under EPICS control)
~ 100 ps by 2 GHz digital scope in persistence mode
~ 3 ps by maximizing THz or photon signal

Diagnostics of laser-electron interaction

Longitudinal electron distribution
⇒ coherent THz radiation [1]







[1] K. Holldack et al., Part. Acc. Conf., Knoxville (2005), 2239.

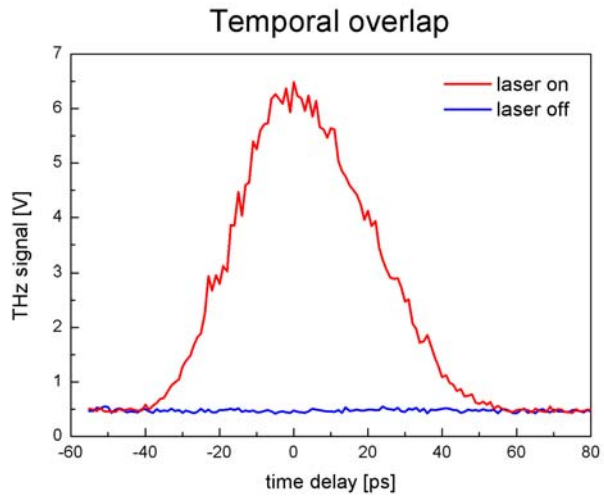
May 9/10, 2006: first sub-picosecond slicing

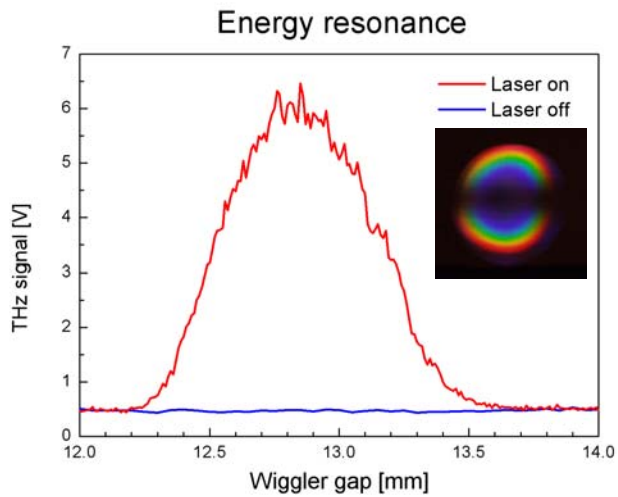
Alignment mode

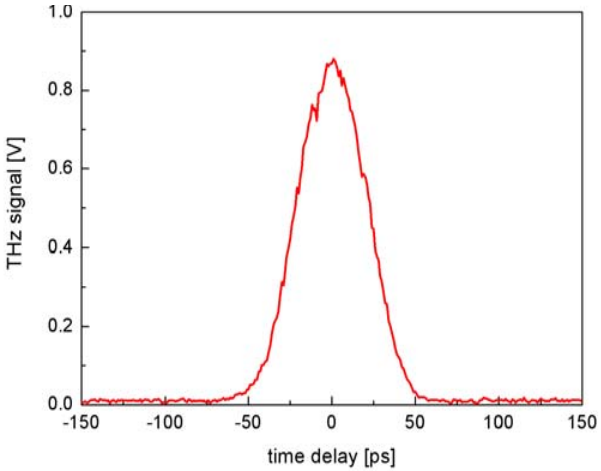
- 3mA single bunch
- laser: 1mJ, 50fs

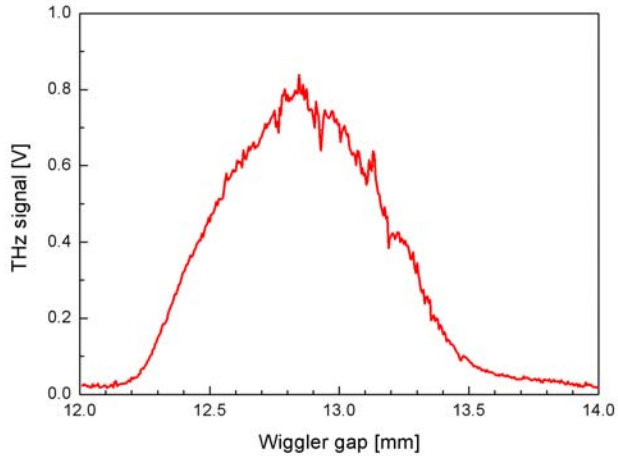
User operation mode

- 300mA multi-bunch
  + 3mA camshaft
- laser: 2.5mJ, 50fs







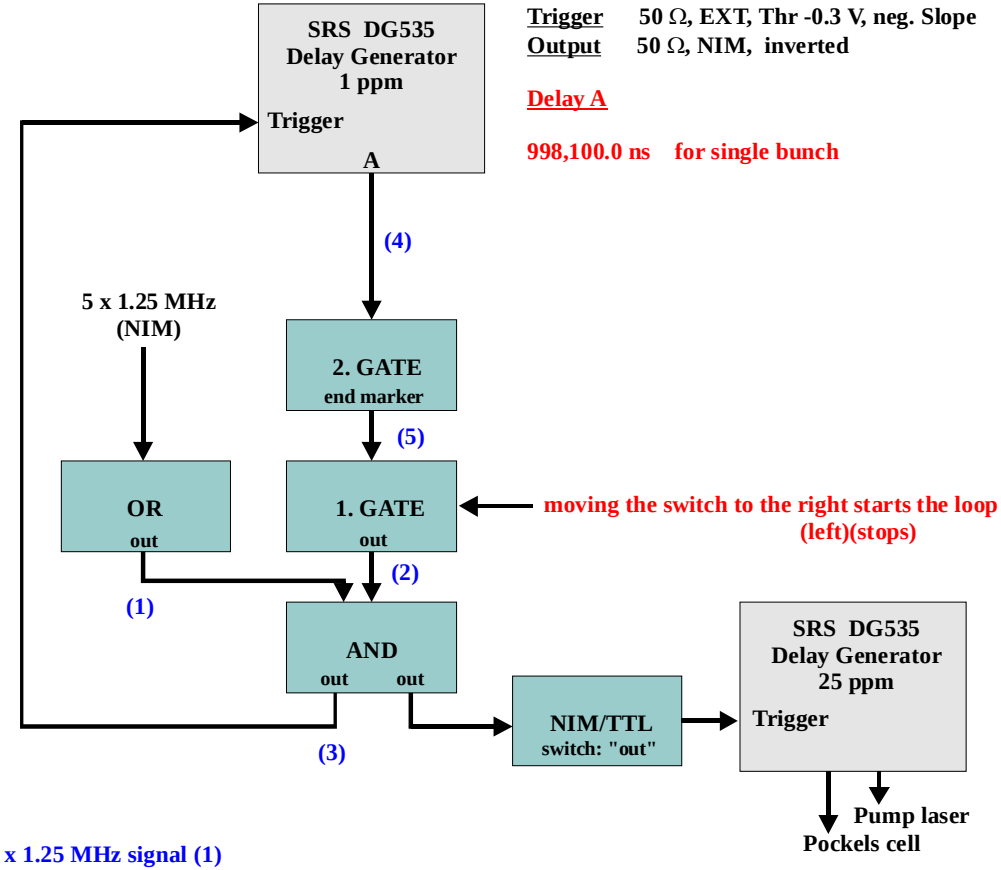


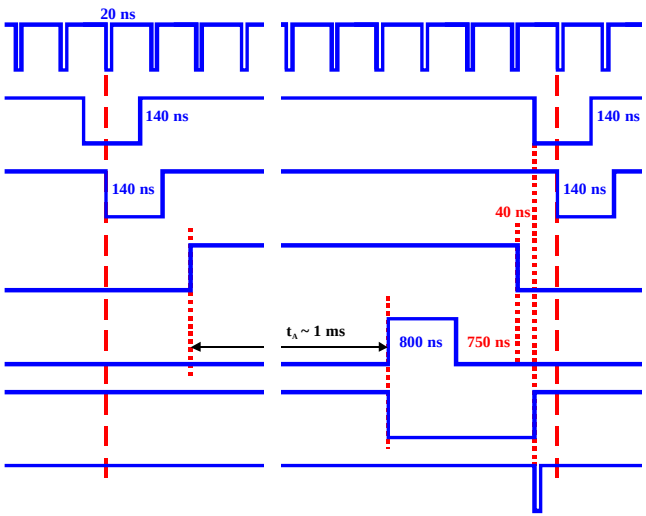
courtesy: G. Ingold, SLS

Laser-electron timing

(2) amplifier pulse selection
- pump laser timing
- Pockels cell timing

select every ~83000-th pulse
(i) counting oscillator pulses
(ii) set a precise delay (1 ppm)





5 x 1.25 MHz signal (1)

output of 1. GATE(2)

AND = DG535 trigger (3)

DG535 BUSY

DG535 output A (4)

output of 2. GATE

end marker of 2. GATE (5)

Laser-electron timing

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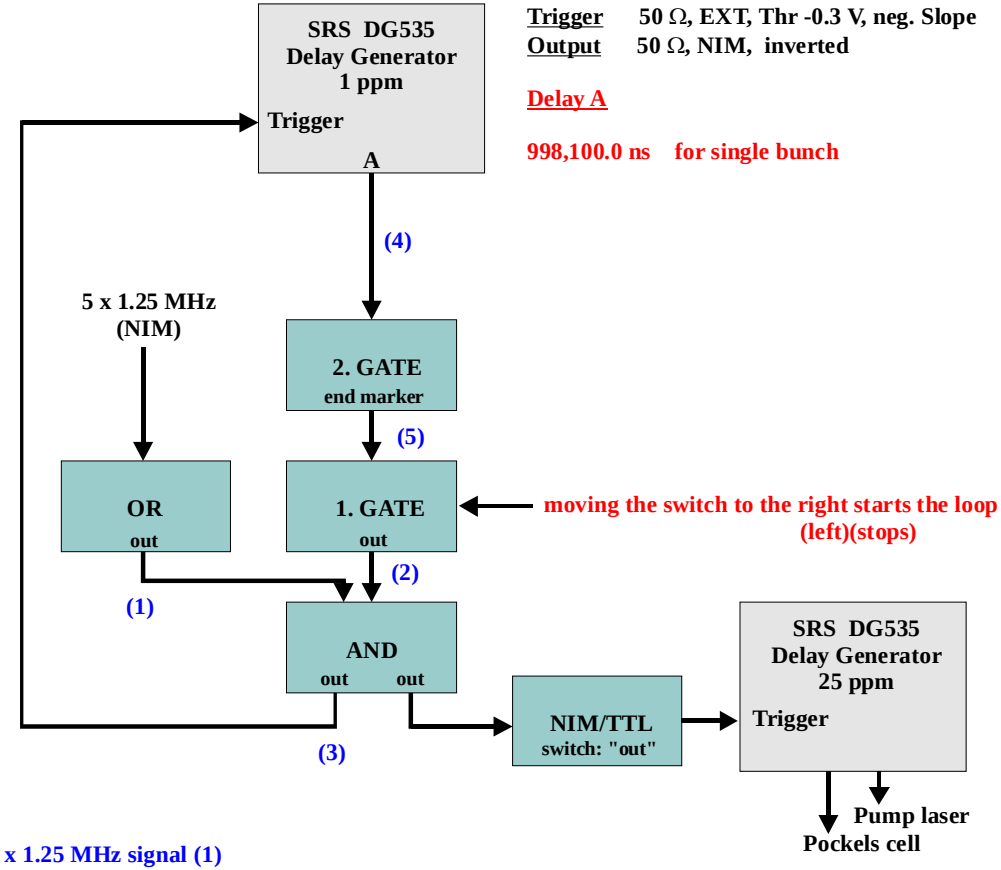

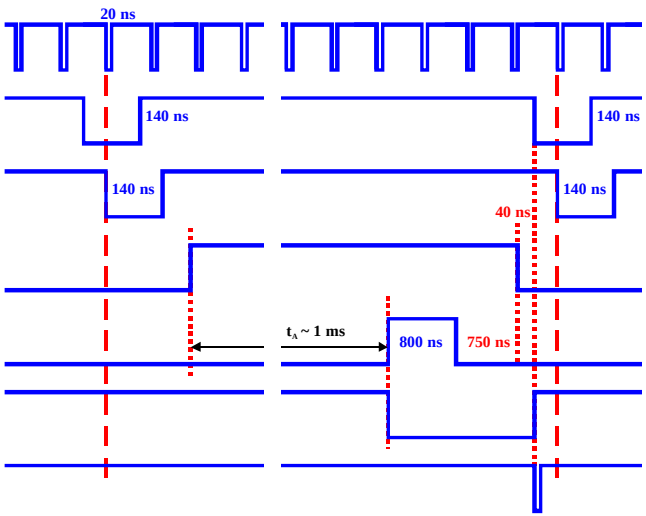

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DG535 output A (4)

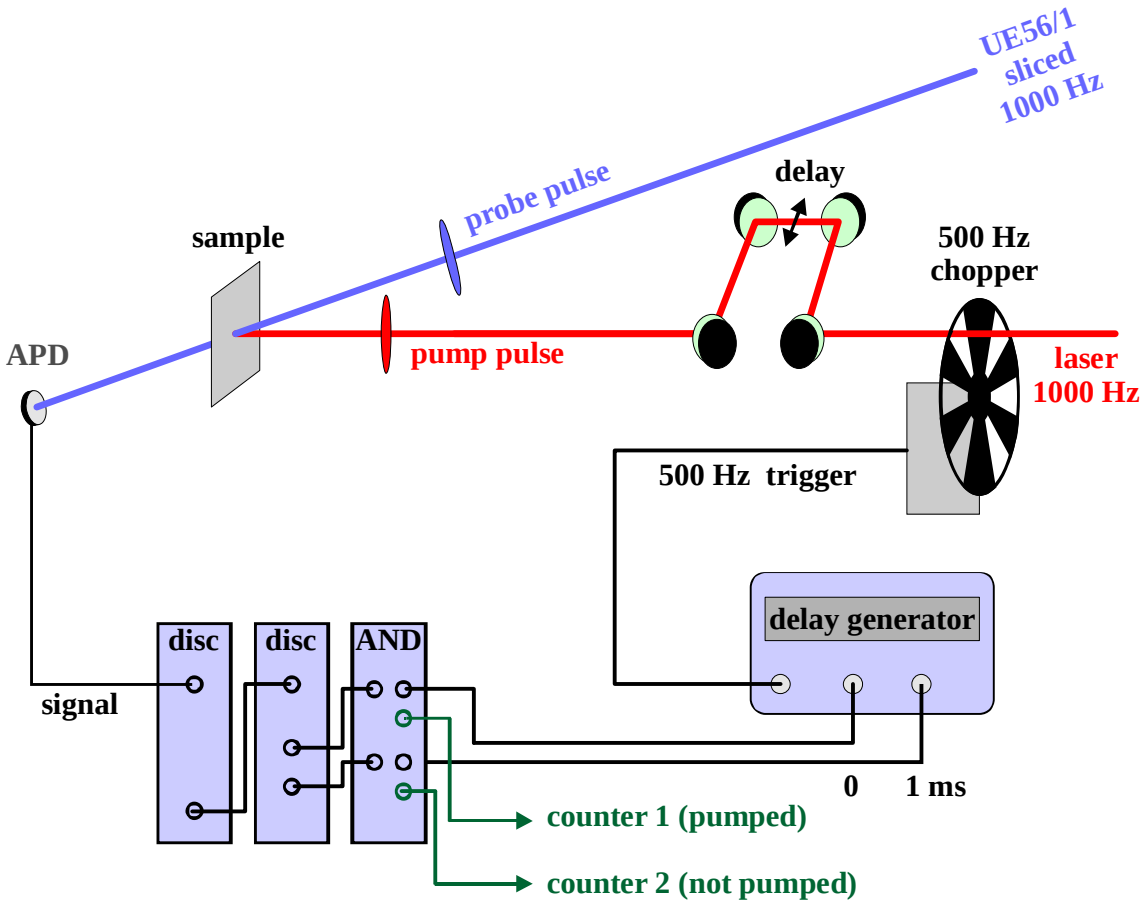
output of 2. GATE

end marker of 2. GATE (5)

Diagnostics:
pump laser timing
- max. amplifier power
Pockels cell timing
- single/double pulse

First pump-probe experiments *(preliminary)*

C. Stamm, T. Kachel, N. Pontius, R. Mitzner, T. Quast, K. Holldack, S. Khan, C. Lupulescu, H. Dürr, W. Eberhardt (BESSY)

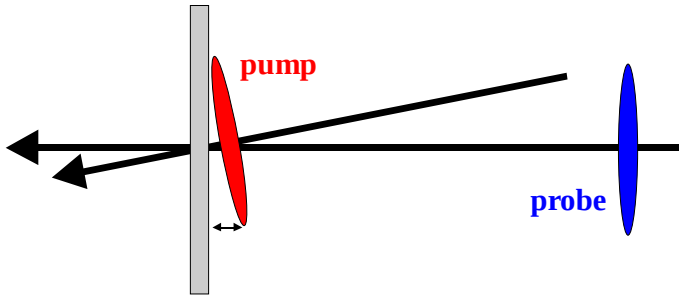


Time resolution ~ 150 fs

Assumed pulse duration 100 fs (FWHM), pulse lengthening:

- monochromator (wavelength • illuminated lines < 30 fs)

- 1º angle between pump and probe pulse



e.g. $\frac{18\,\text{mrad}\cdot 1\,\text{mm}}{c} = 60\,\text{fs}$

- path length changes over 8 hrs and 40 m

e.g. $30\,\mu\text{m}/c = 100\,\text{fs}$

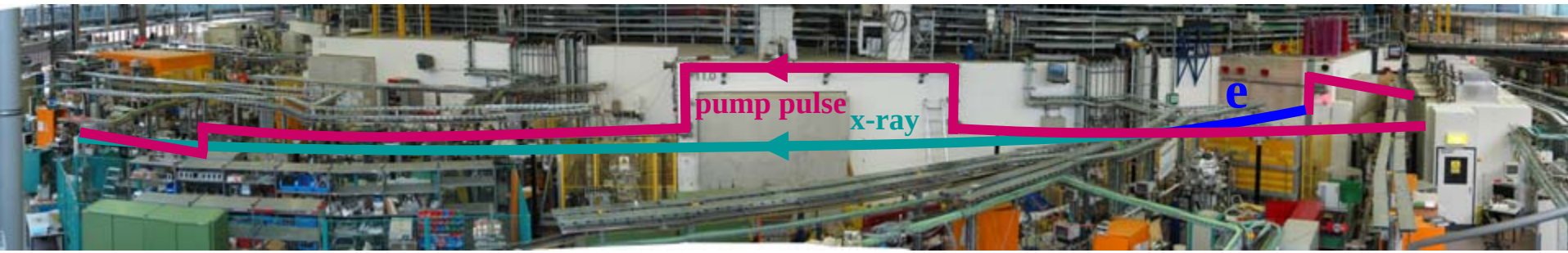


photo: K. Godehusen

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I. Hertel, F. Noack, W. Sandner, I. Will, N. Zhavaronkov (MBI, Berlin)
***) commissioning team**

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