ATF kicker studies

2005/08/17
KEK T.Naito

1. ILC Kicker parameters
2. Measurement set up
3. Measurement result
    - FID FPG5-3000M
    - DESY pulser
    - Livermore pulser
4. Summary

ILC kicker requirement

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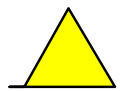
TDR parameters

Kick angle	~0.6mrad or	$Bdl \sim 0.01 Tm$@5GeV, ~50m
Stability	7×10^{-4}	
Rep. Rate	3MHz (or 6MHz)	
Rise time of pulse	3ns(L_{DR}=3km), 6ns (L_{DR} =6km) 20ns(L_{DR} =17km)	

Parameters



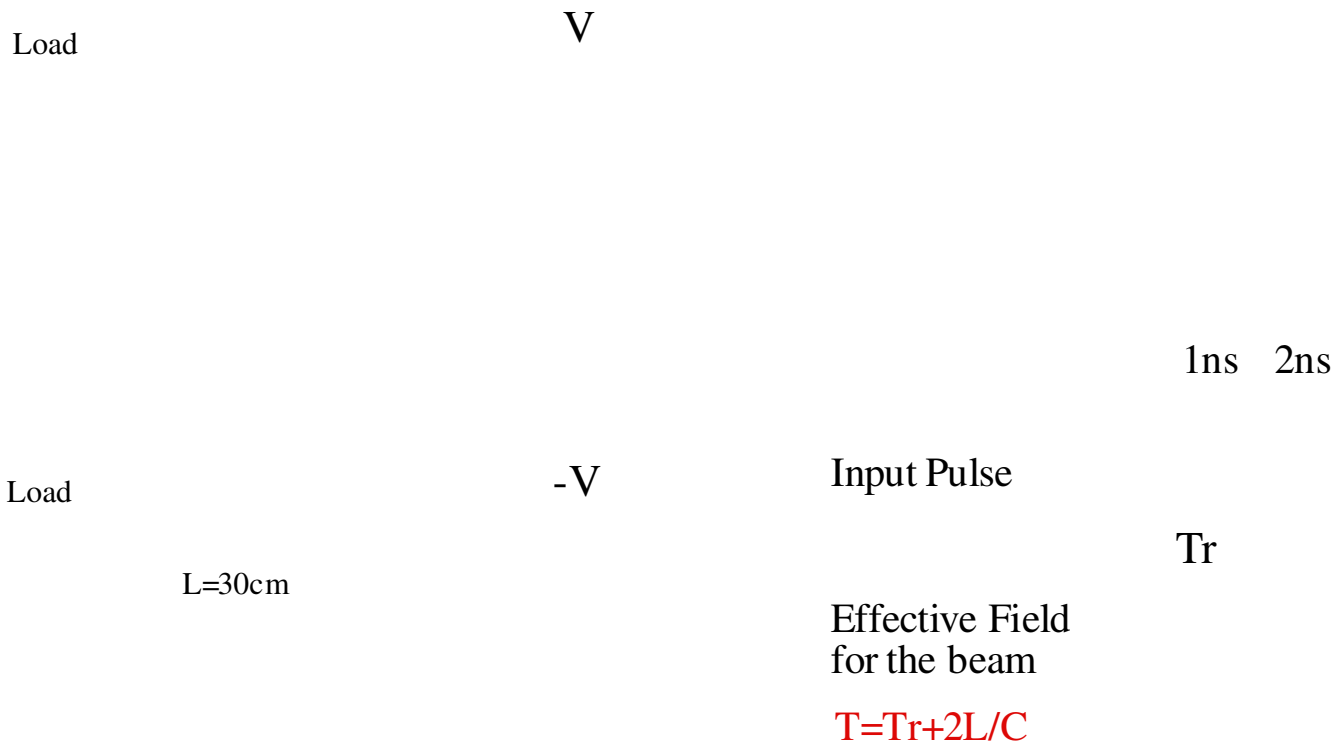
kicker pulse
Rise time < bunch spacing

Strip-Line kicker

2L/C=2ns
Rise time of the effective field

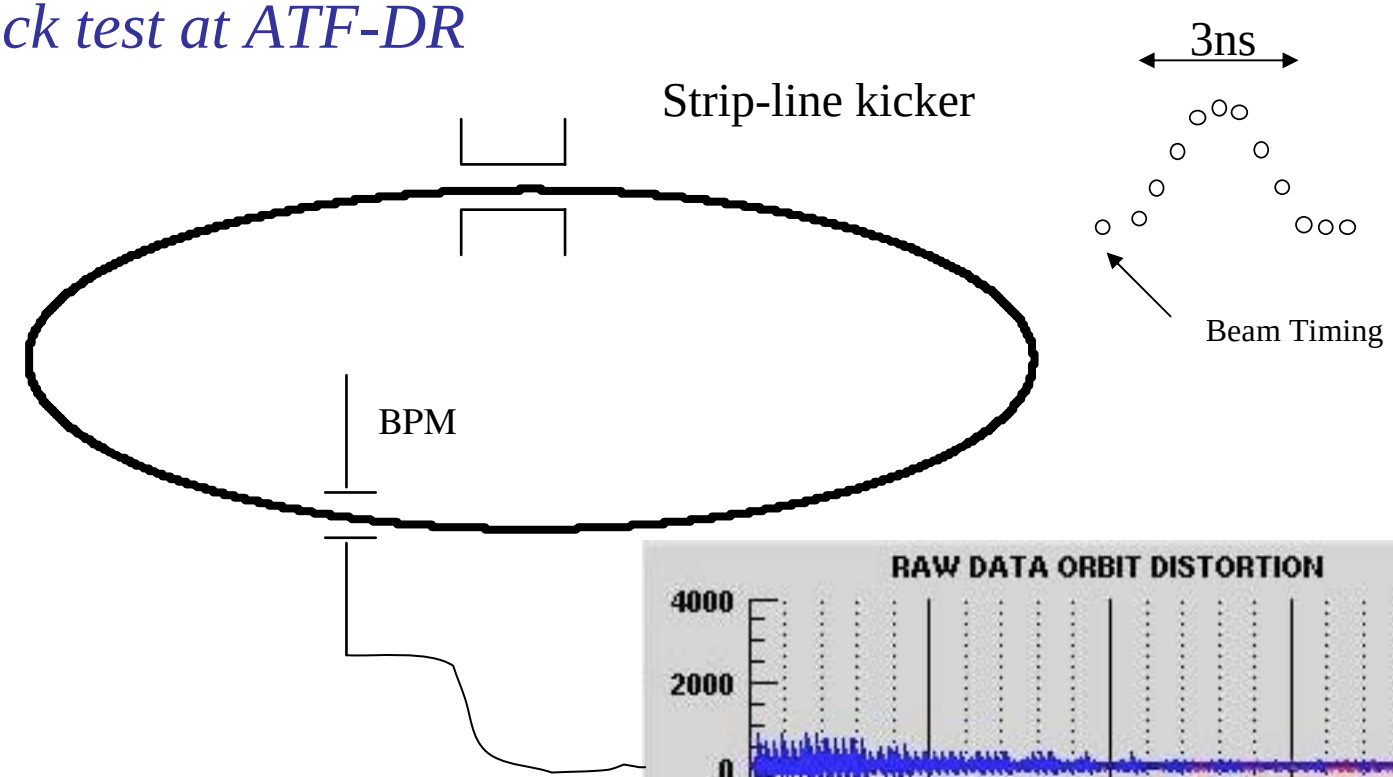
0.01Tm with 0.

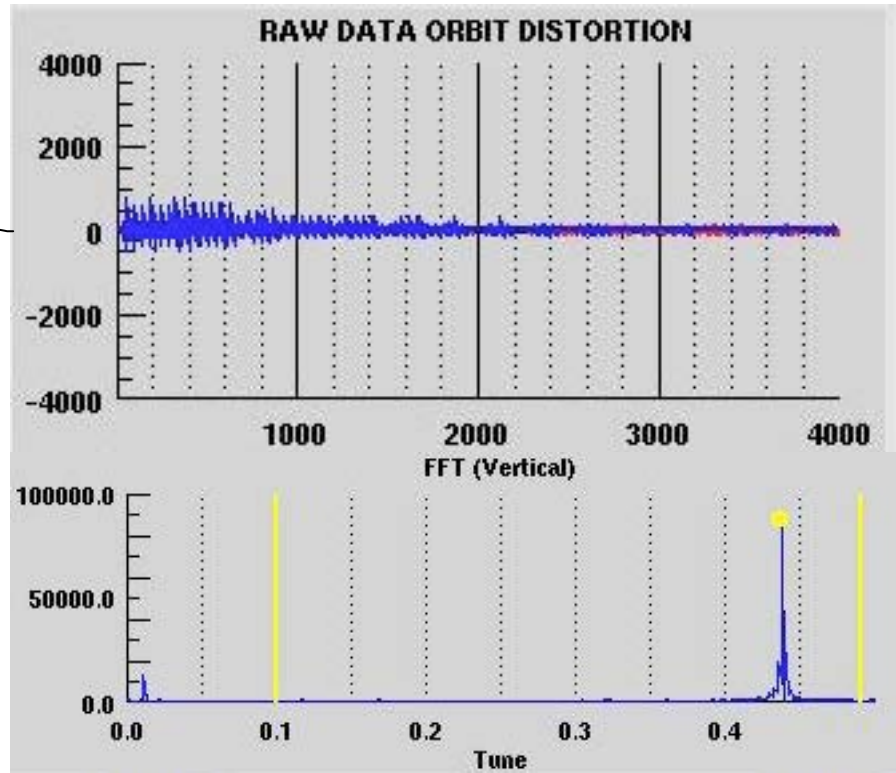
Rise time of the kicker field



When the kicker pulse is applied to the electrode for the counter direction to the beam, the rise time of the field is required to T=2L/C. Where L is length of the electrode and C is a speed of light. If the pulse has the rise time, Tr, the field is a summation of the rise time of the field in the electrode and the rise time of the pulse.

Beam kick test at ATF-DR

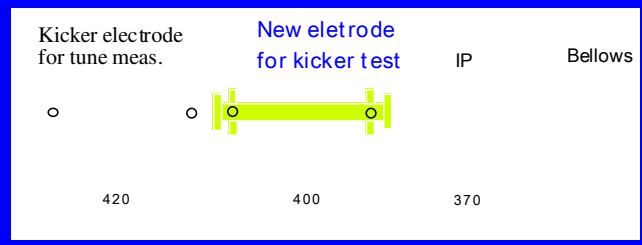




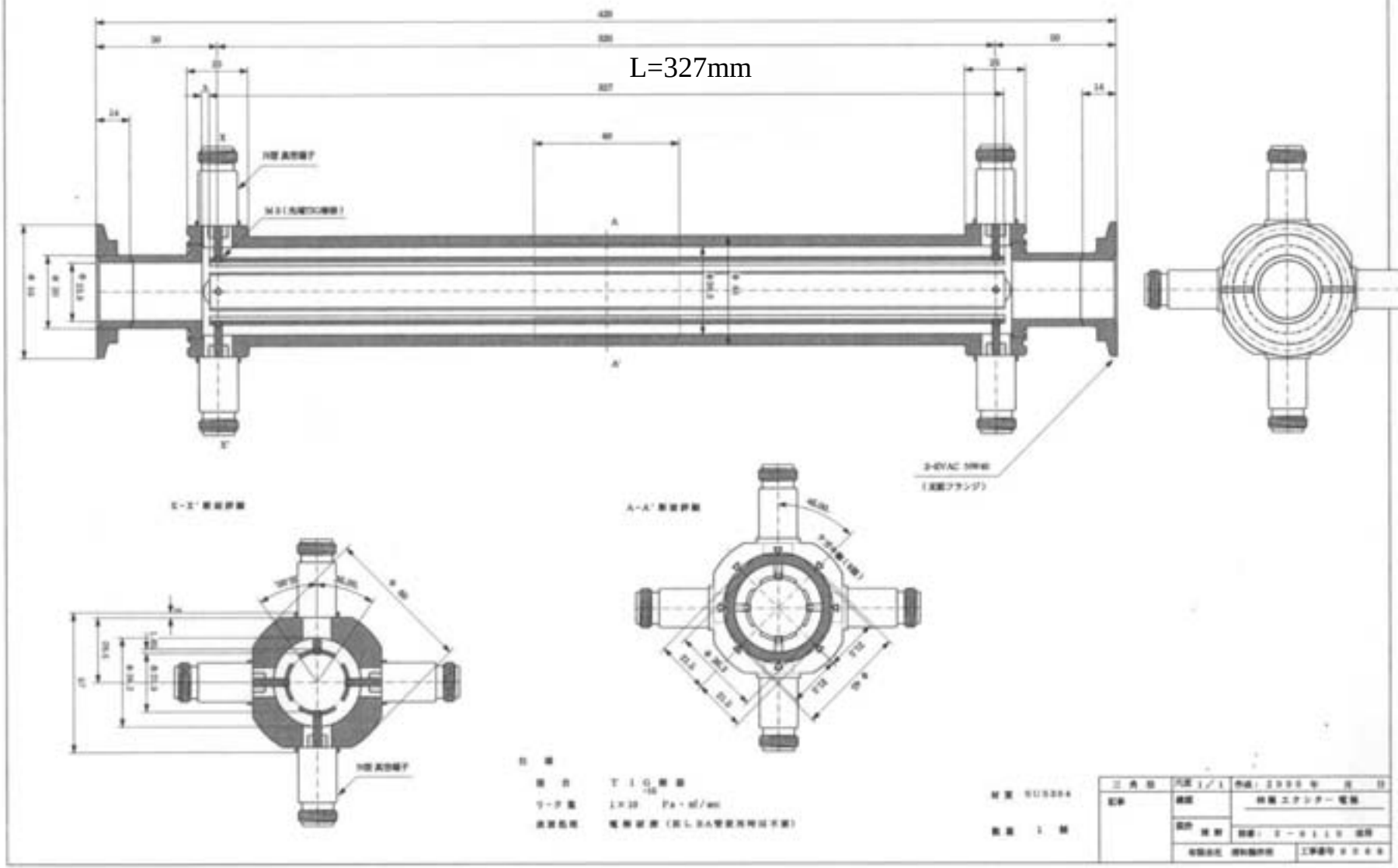
The kicker pulse is applied to the strip-line electrode at just the time of the beam goes through the electrode.
The beam kick is observed by a turn-by-turn BPM as the amplitude of the oscillation of the betatron frequency component. This measurement is a kind of filtered signal measurement, therefore this method is accurate compare to the simple position measurement.
The kick effect is measured by scanning the pulse timing.

Beam kick test at ATF

Location of the strip-line electrode in the damping ring



ATF Kicker chamber for beam excitation



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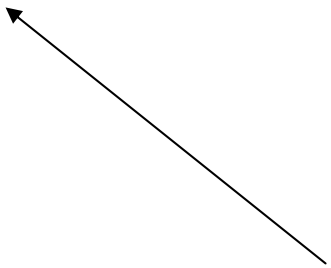
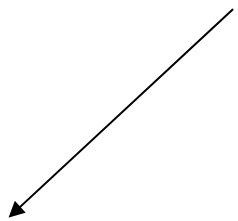
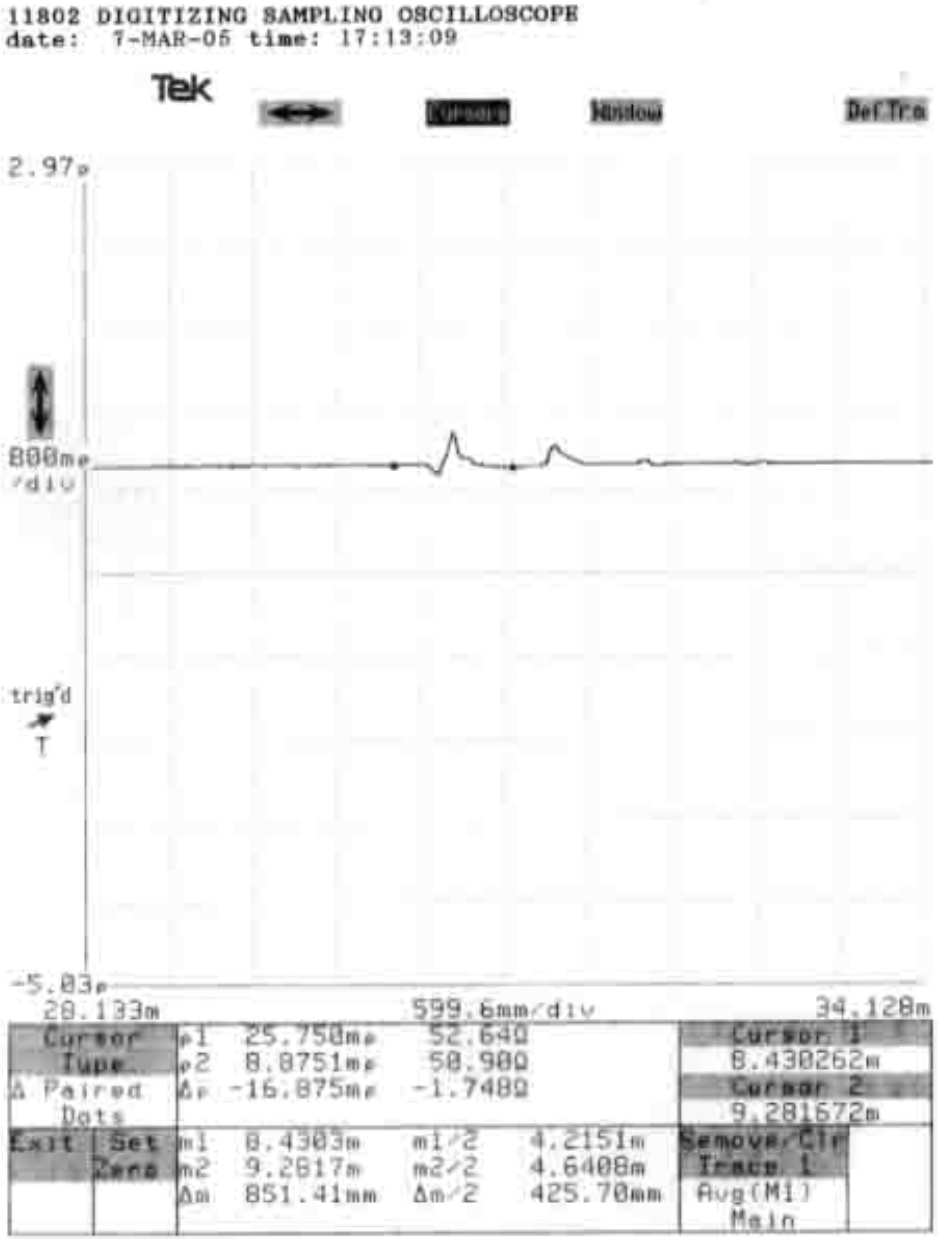


Strip-line
Electrode

Pulse Power supply

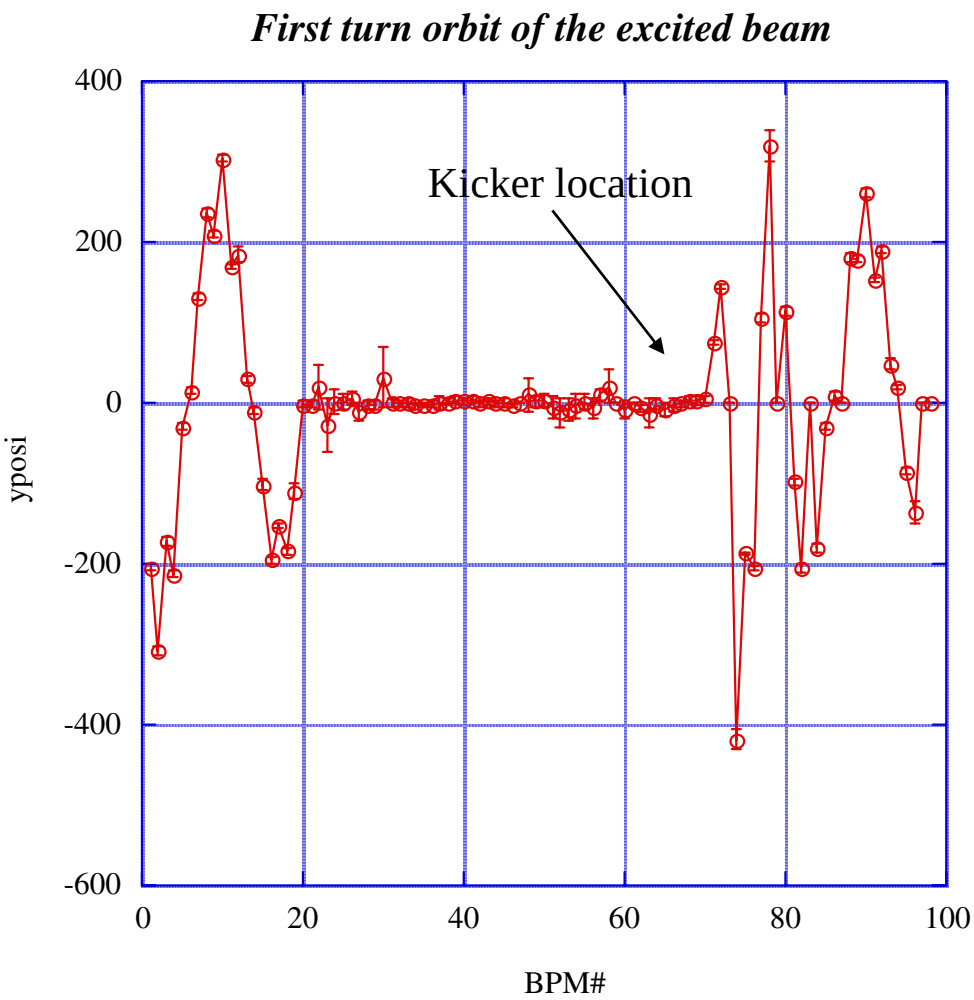


TDR measurement of the strip line electrode



The measured impedance of the strip-line is 52ohm.

Kick angle measurement



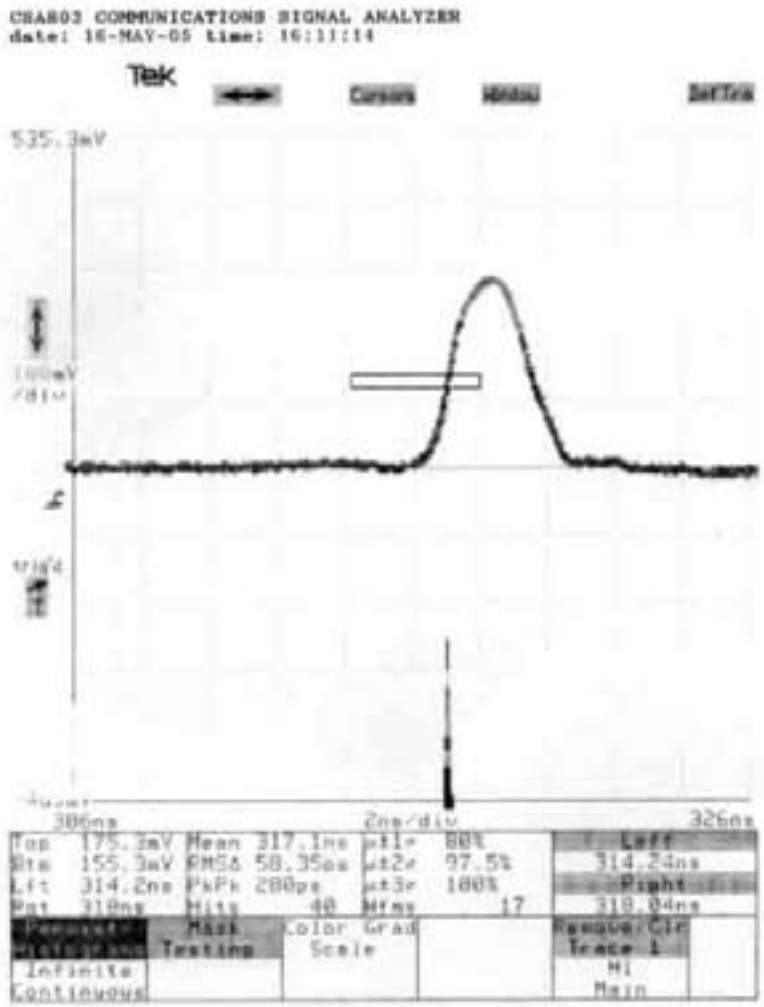
The amplitude measurement of the betatron oscillation has a good S/N ratio, however it is difficult to calibrate the absolute kick angle from this measurement.

The calibration was done by one-turn BPM signal which just kicked orbit and the transfer matrix. The graph shows the orbit just after applying the kicked pulse when the timing of the pulse is adjusted to the peak.

FPG5-3000M pulser(FID GmbH)

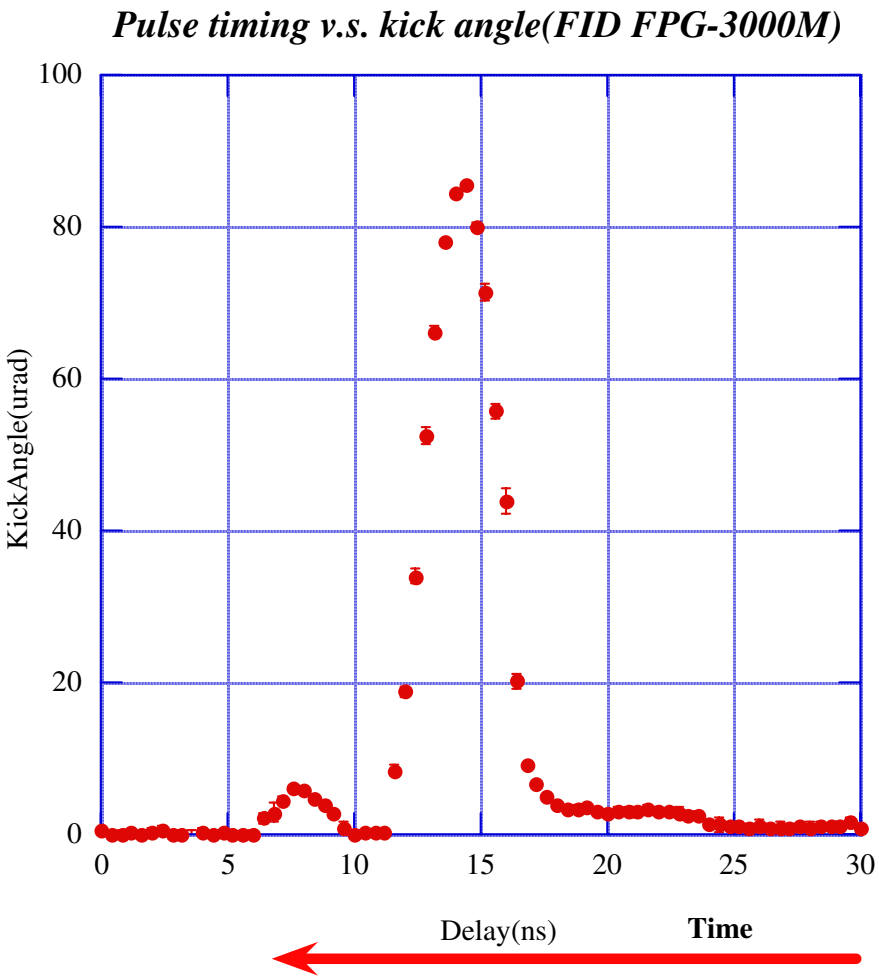
Specifications

Maximum amplitude at 50 ohm - 5 kV
Rise time - 1-1,2 ns
Pulse width at 50% of amplitude - 2-3 ns
Polarity - negative or positive
Delay time between output pulse and triggering
- not more than 200 ns
Jitter - not more than 100 ps
Triggering - Internal and External - 5-15 V, 10-20 ns
Maximum PRF in burst mode - 3 MHz

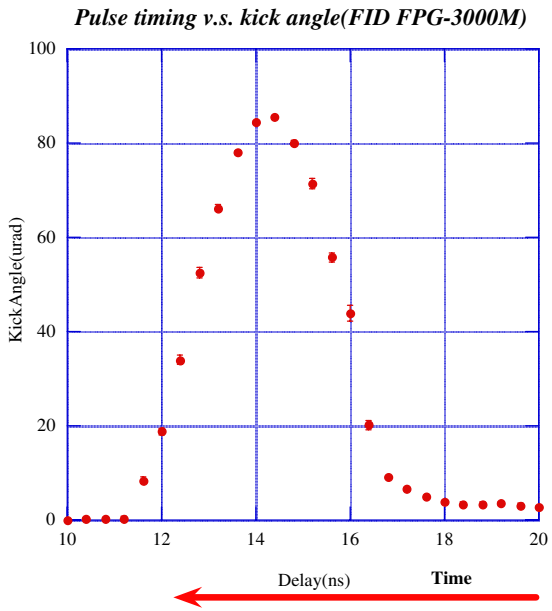


5kV, ~1.5ns rise time

Measurement result of FPG5-3000M

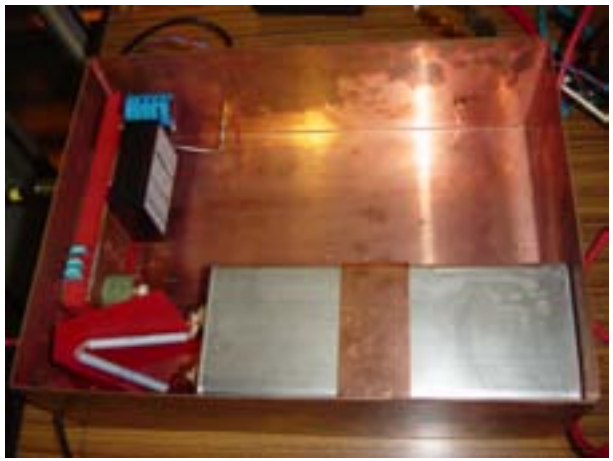


Rise time~3.2ns
Kick angle ~85 rad
(calc. 94.7 rad)



Expanded horizontal scale

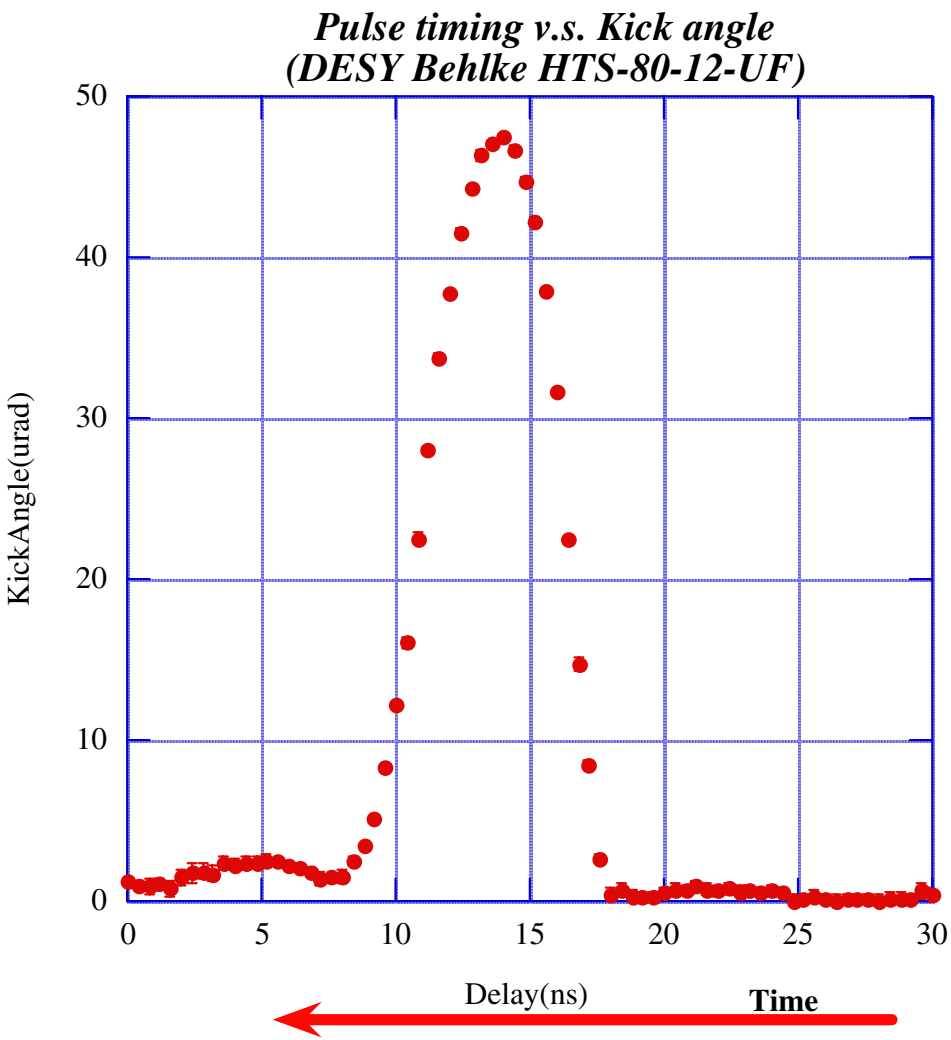
DESY pulser 2005/05/18~05/20



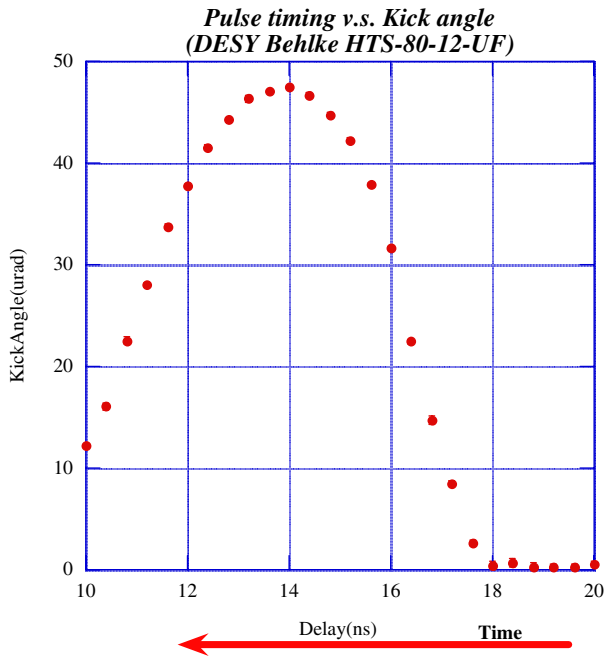
BEHLKE ELCTRONIC GmbH,
HTS-50-08-UF
5ns pulse width

2.5kV peak, 2.5ns rise time
1MHz, 500pulses

DESY pulser(HTS-50-08-UF)

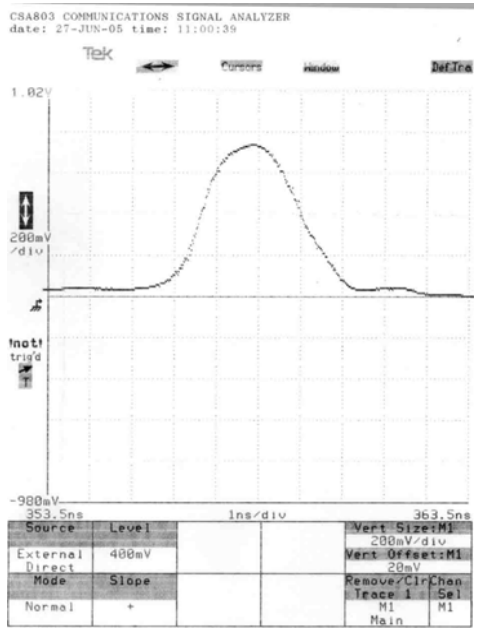


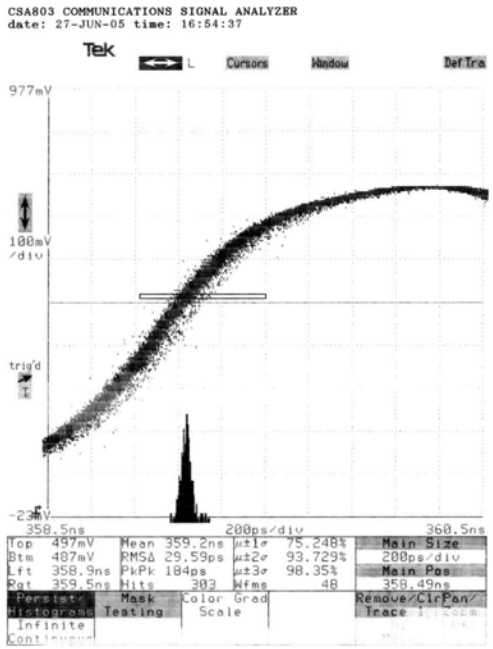
Rise time ~4ns
Kick angle ~47.5 rad
(calc. 47.35 rad)



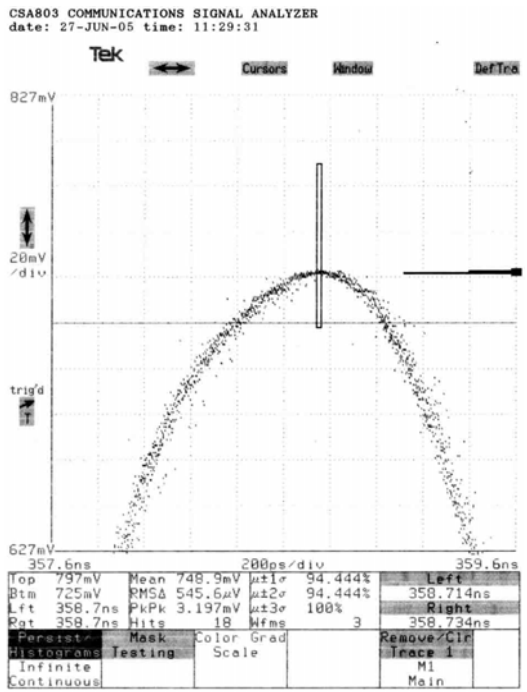
Expanded horizontal scale

Pulser characteristics

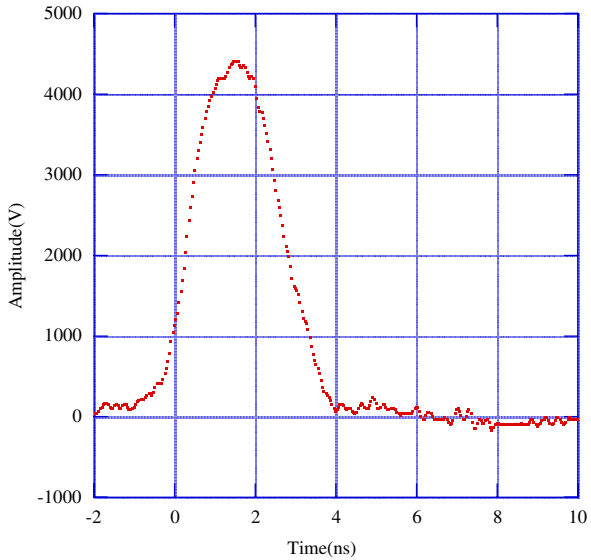


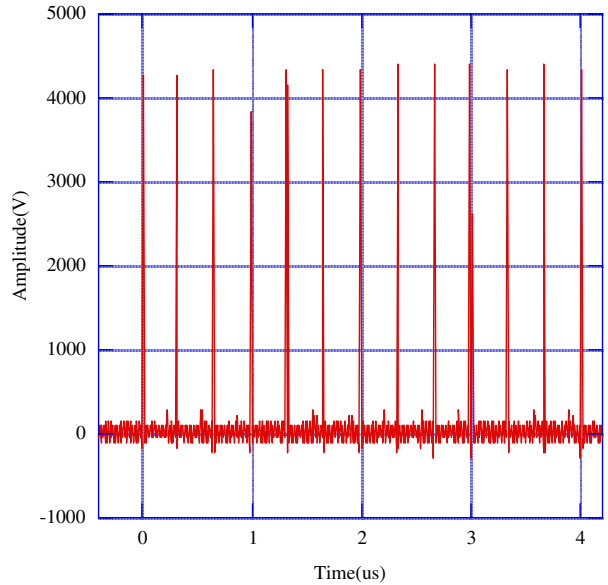


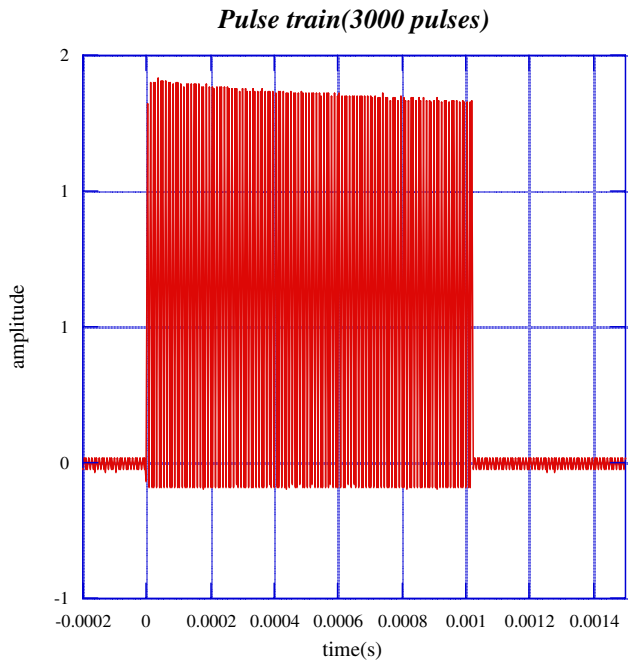
FID(FPG5-3000M) pulser
Pulse width(FWHM) = 2ns
Pulse height = 5kV
Rise time = ~1.5ns
Time jitter = ~29 ps
Amplitude Jitter = 0.72%
(limited by the scope resolution)



FPG-3000M 3MHz, 3000plses







*The 4th pulse is ~10% smaller than the others.
*A few % of droop was observed in the 3000pulse train.

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DESY pulser
Pulse width(FWHM) = 5ns
Pulse height = 2.5kV
Rise time = ~2.5ns
Time jitter = ~26 ps
Amplitude Jitter = 0.4%
(limited by the scope resolution)

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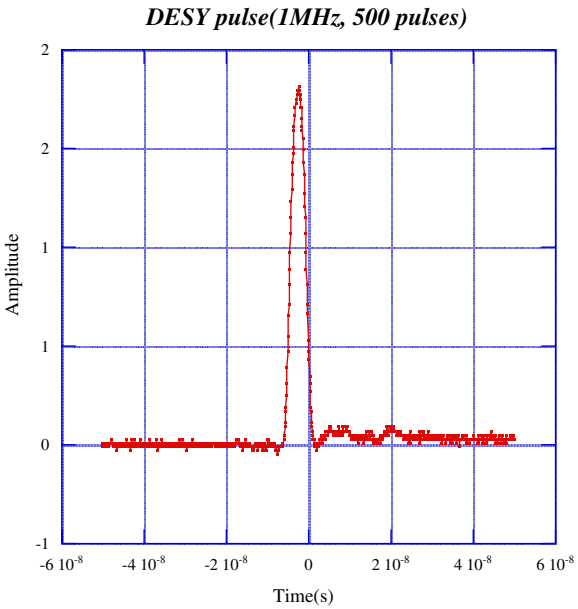

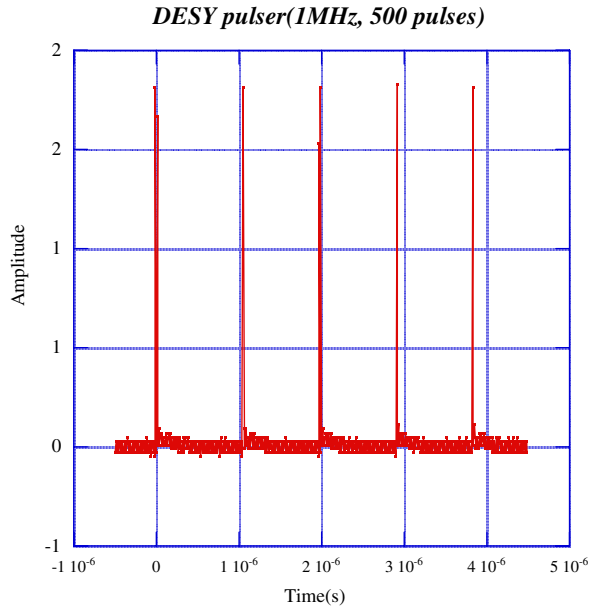

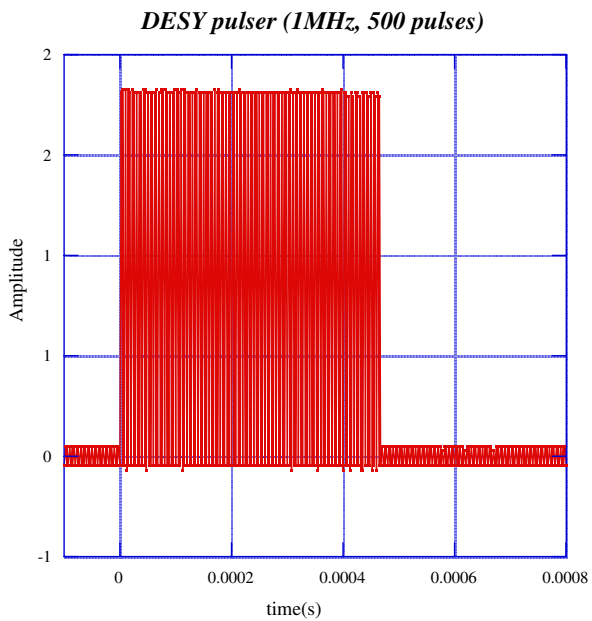

The droop of the 500pulses is 5x10-3.

Amplitude stabilization of the burst pulses(1)

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The changing of the pulse amplitude from the first pulse to the end pulse is simulated. The pulse amplitude dropped by 0.5% between the 500pulses.

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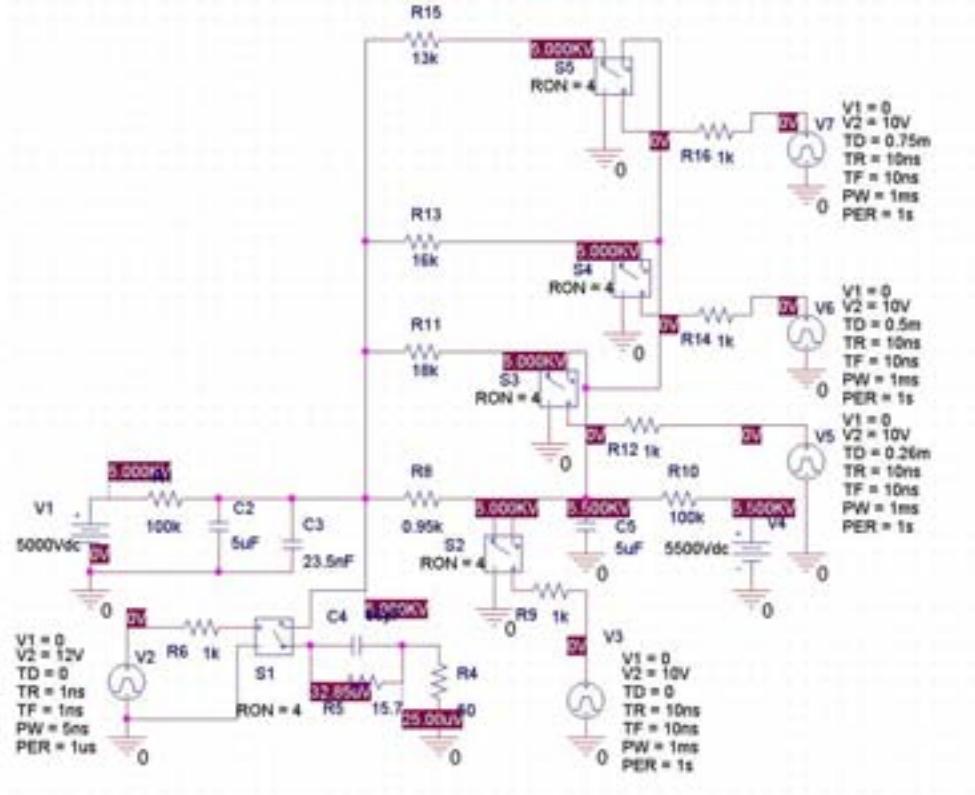
Amplitude stabilization of the burst pulses(2)



When compensation circuit is added to the DC high voltage power supply, the pulse amplitude is stabilized to 6x10^-5 between the 500pulses. The stability meets with the ILC specification.

LLNL pulser (Anatoly Krasnykh (SLAC))

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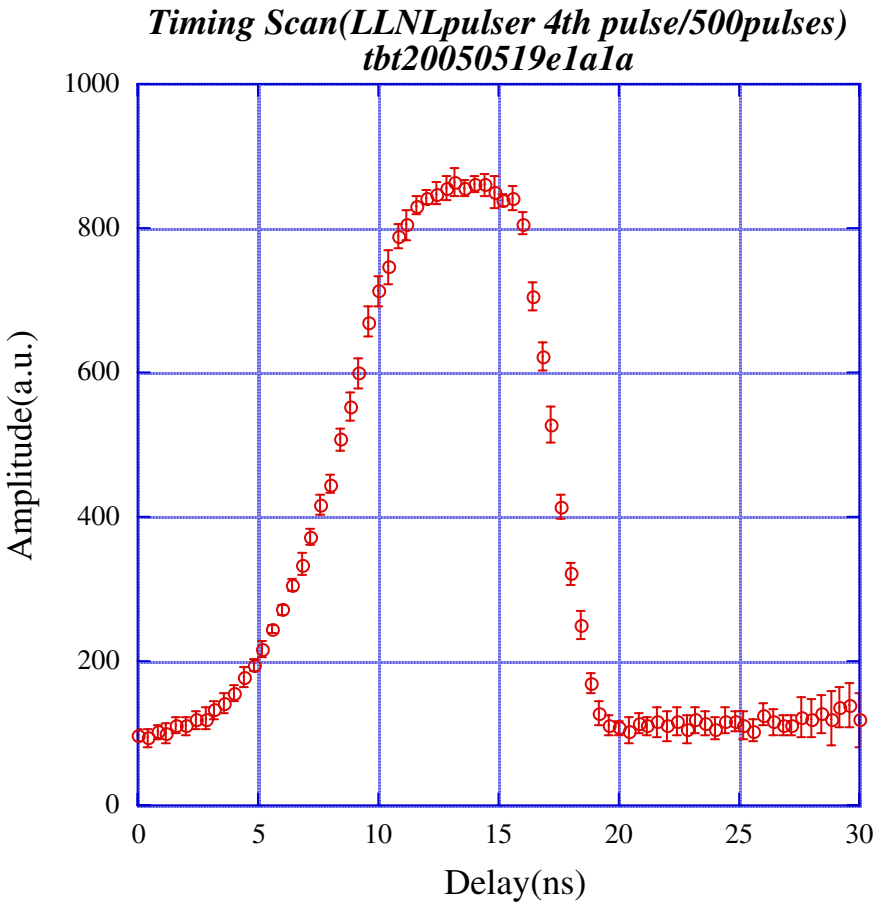
Slid state switch bank developed by LLNL

+/-3.1kV, 500kHz, 500pulses
~4ns rise time, 10ns pulse width

Timing Scan(LLNL pulser)



Rise time ~5ns

Summary

The ILC kicker study has been carried out at ATF-KEK as an international collaboration(KEK, SALC, DESY, LLNL, etc.).

The range of ~3ns rise time of the beam kick and 3MHz operation of the pulser was successfully confirmed which shows the realistic prospect of the 3km circumference DR design.

Following study items need to optimize the kicker design.

1) Pulser - rise time improvement, pulse number, elimination of the droop, etc.
2) Strip line electrode design - length, shape, feed-through, etc.
3) Stability - confirm by the beam test
4) Consider the 6MHz operation