Fast Kicker R&D at ATF

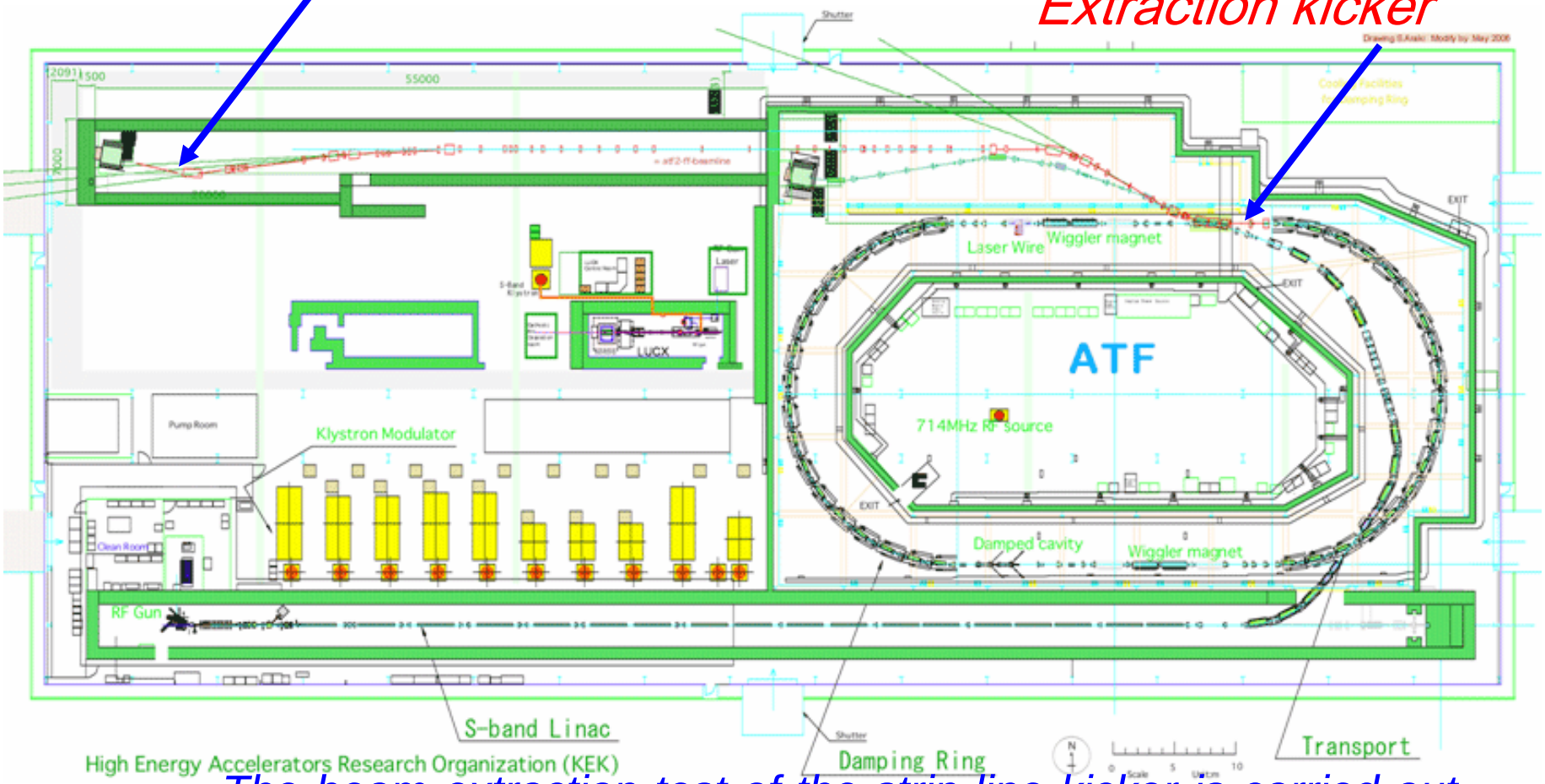
T.Naito(KEK)

TILC09 18/April/2009

Experiment at ATF2

ATF2 - 40nm beam production, measurement

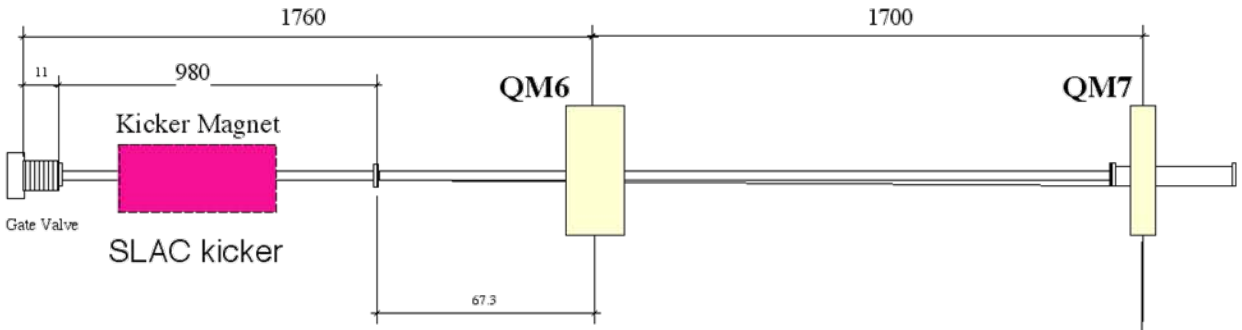
Extraction kicker

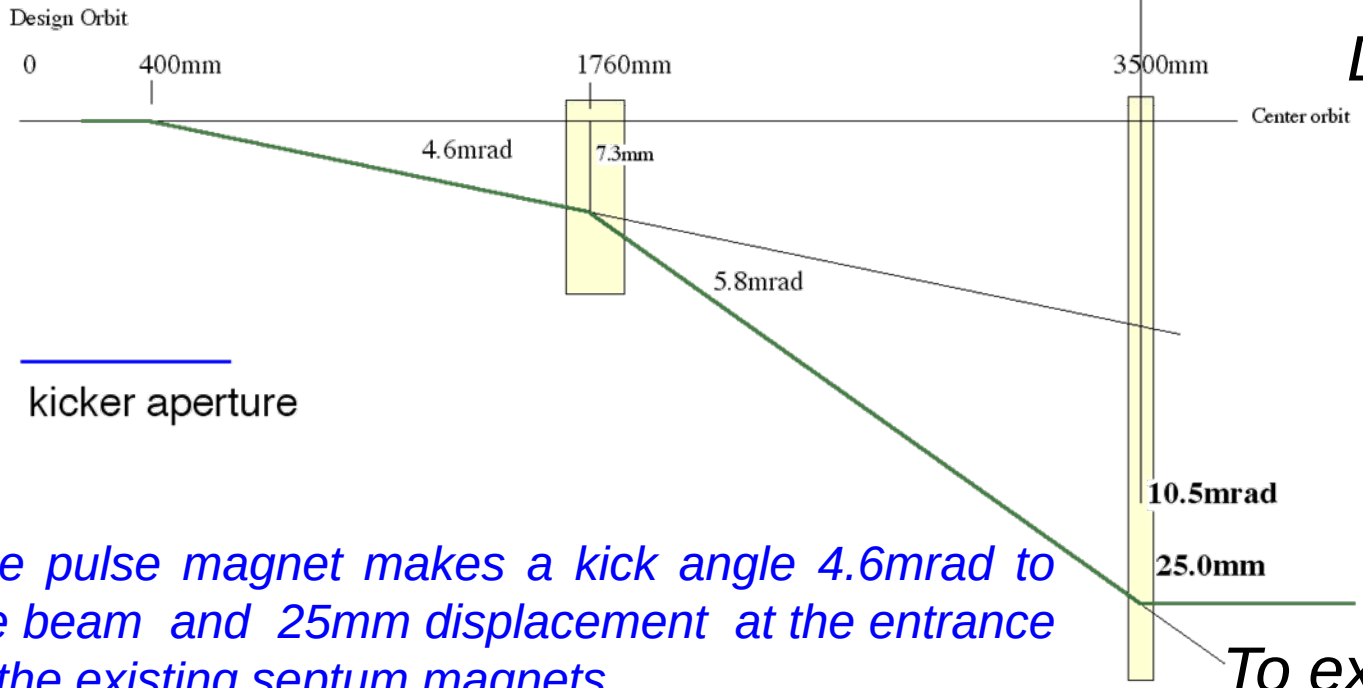


The beam extraction test of the strip-line kicker is carried out by replacing the pulse magnet of the extraction kicker. The problem is that the kick angle of strip-line kicker is not enough compared to the kick angle of the existing pulse magnet.

Present layout

20051221 T.Naito



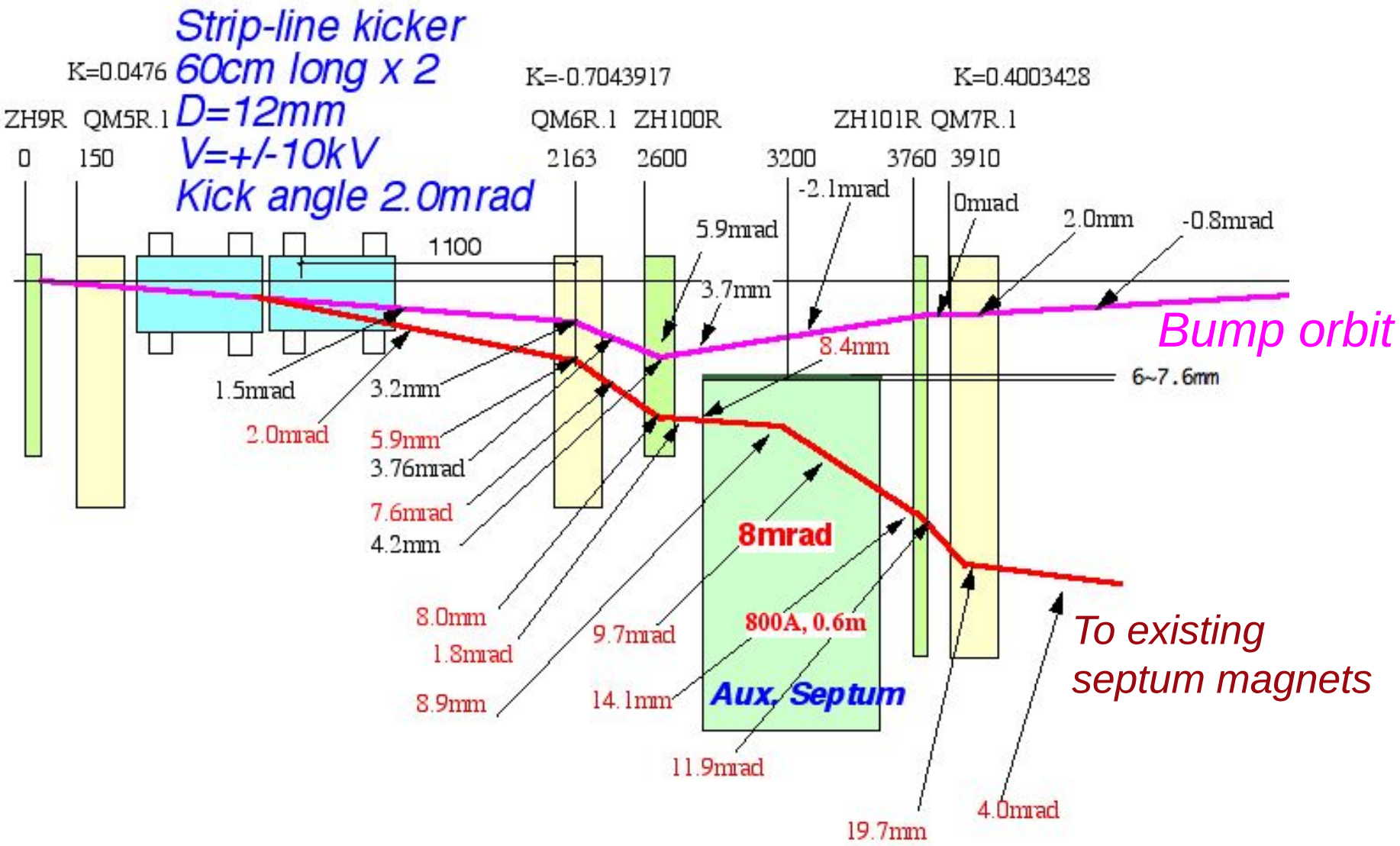


DR orbit

The pulse magnet makes a kick angle 4.6mrad to the beam and 25mm displacement at the entrance of the existing septum magnets.

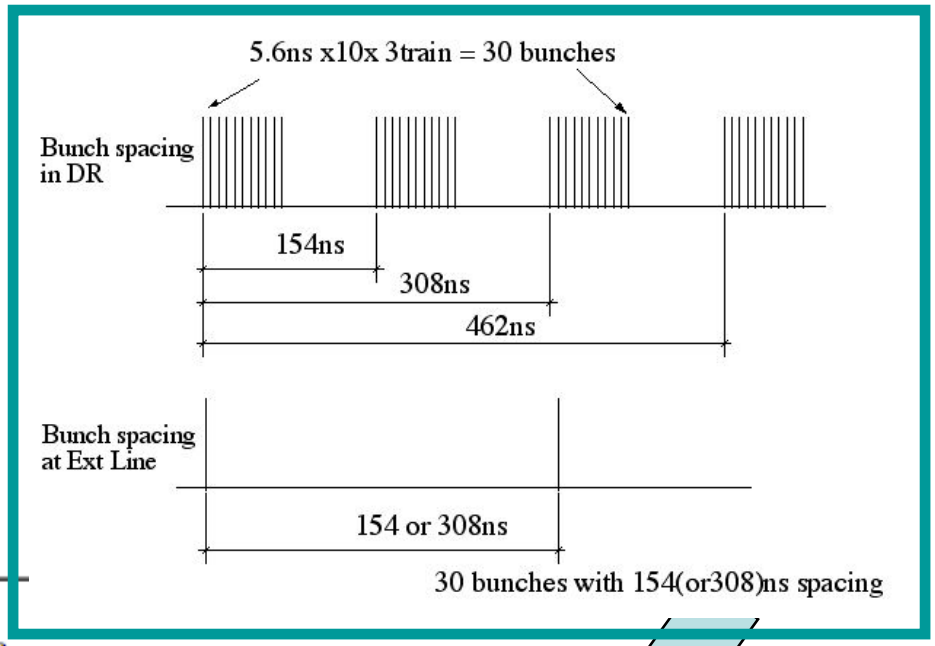
To existing septum magnets

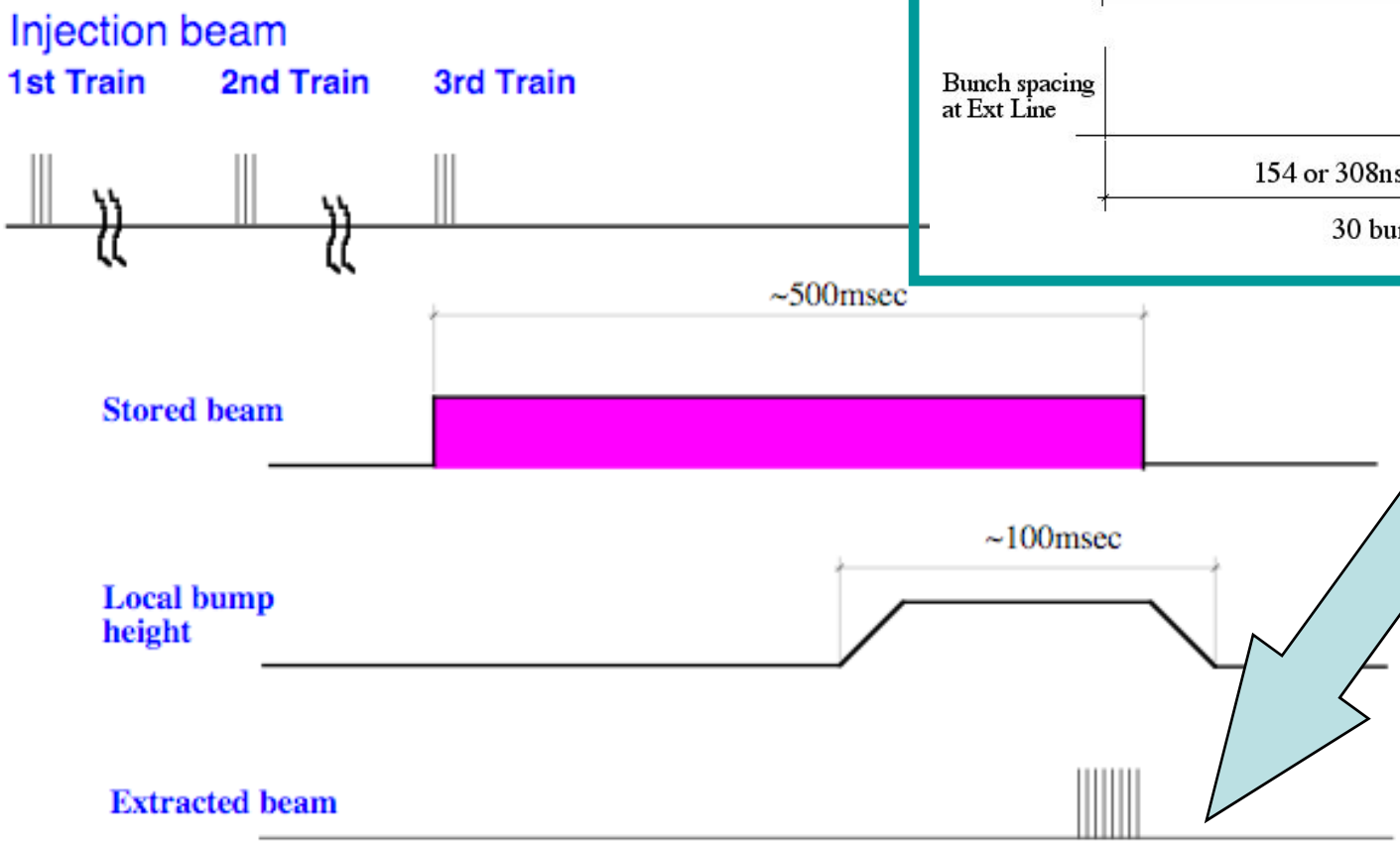
Orbit by using Strip-line Kicker & bump



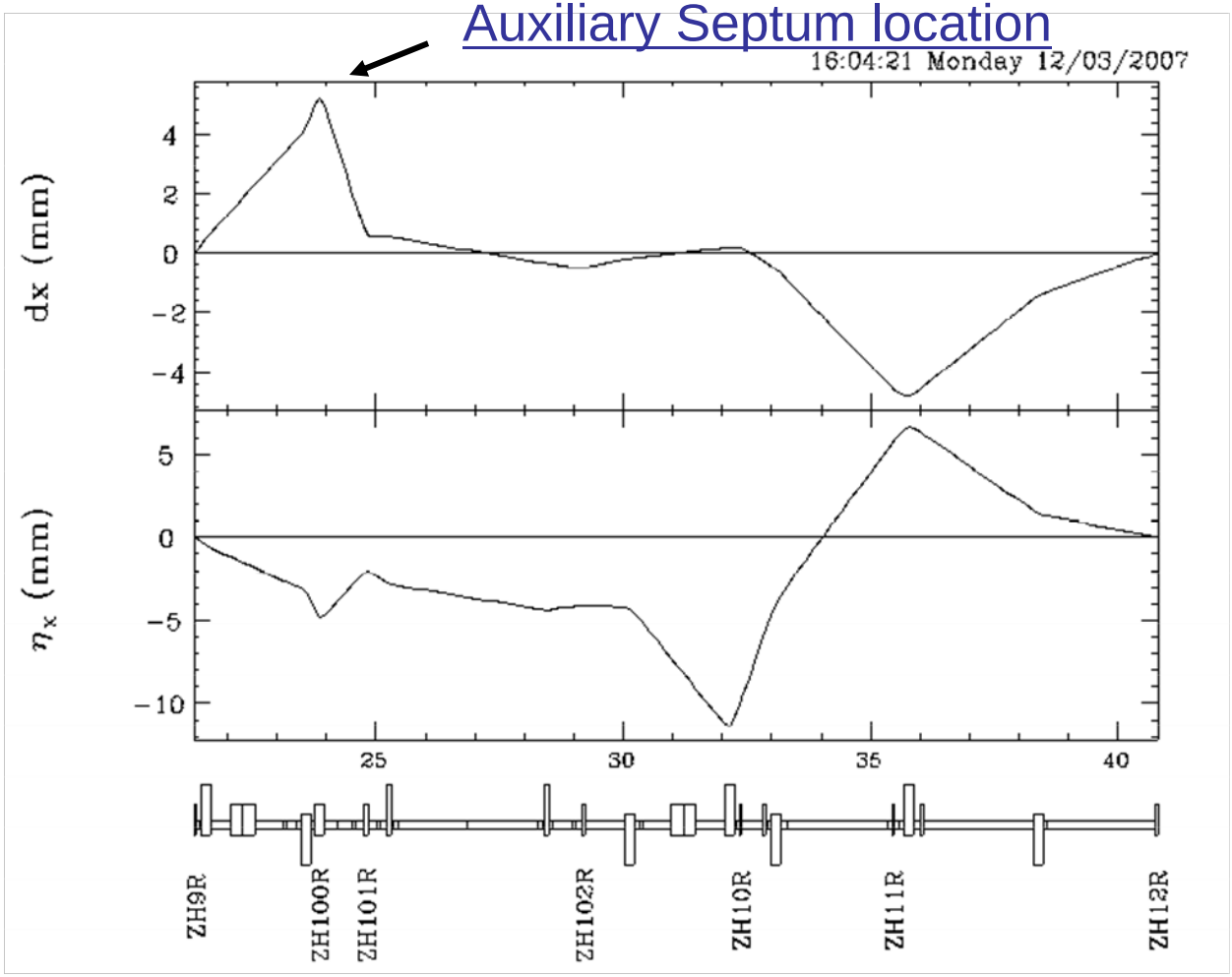
Timing chart of 30 bunches beam extraction

The bump orbit is gradually changed after all of the bunches have been damped. The strip-line kicker kicks out the beams at the timing of the flat-top of the bump orbit. The beams are extracted as one long bunch train, which is a 10micro-sec long with 154ns (or 308 ns) bunch spacing.





Optics design of Orbit Bump with 7 Correctors



dx=5mm@ZH100R

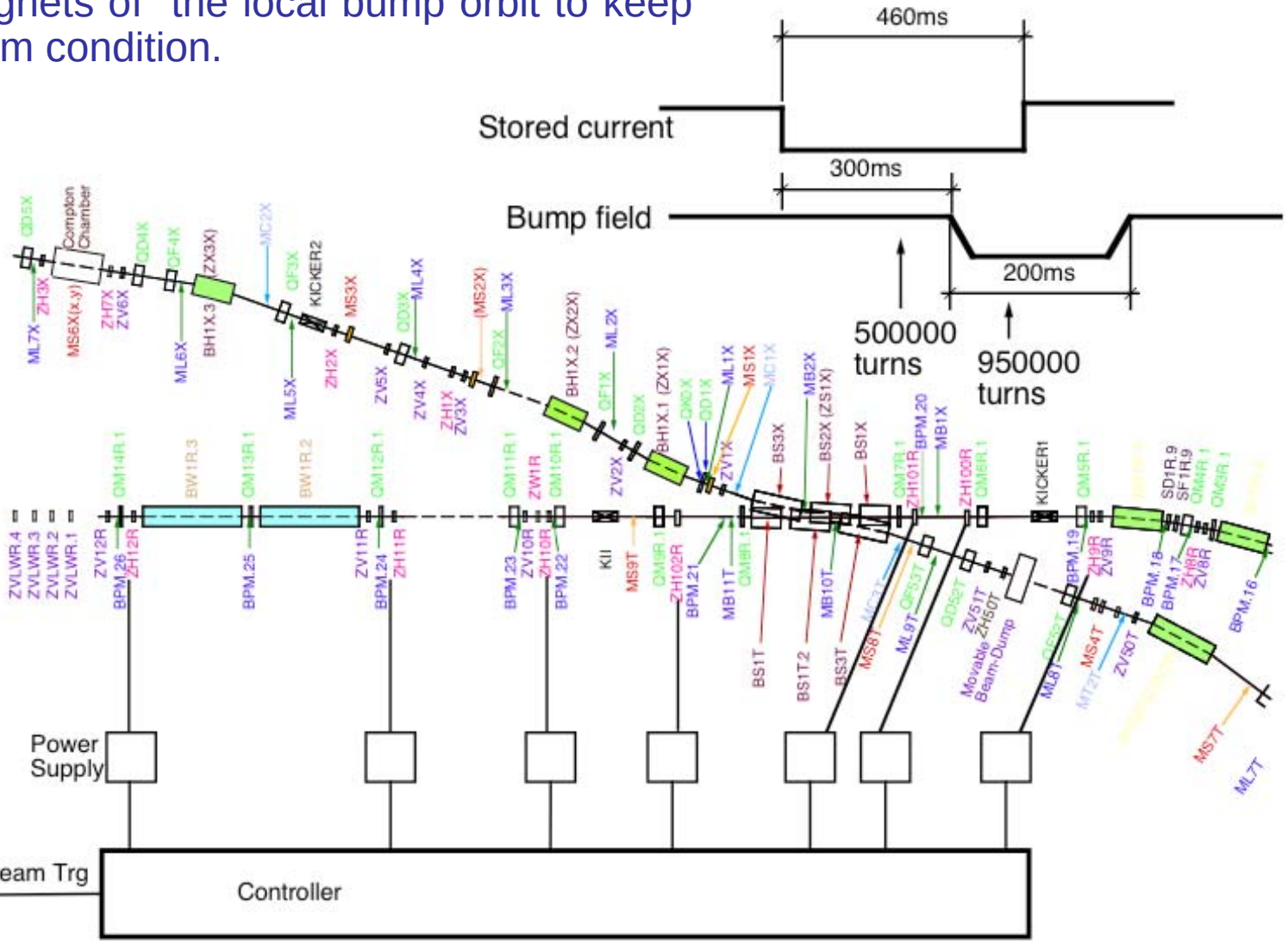
ZH9R	-.002320433716
ZH100R	.010028367995
ZH101R	-.005102712636
ZH102R	-5.52689273E-4
ZH10R	.001010243282
ZH11R	-7.88468363E-4
ZH12R	5.883103424E-4

Abs[dx] between septum and INJ.Kicker (from LSEP.1to IIN) < 0.5 mm

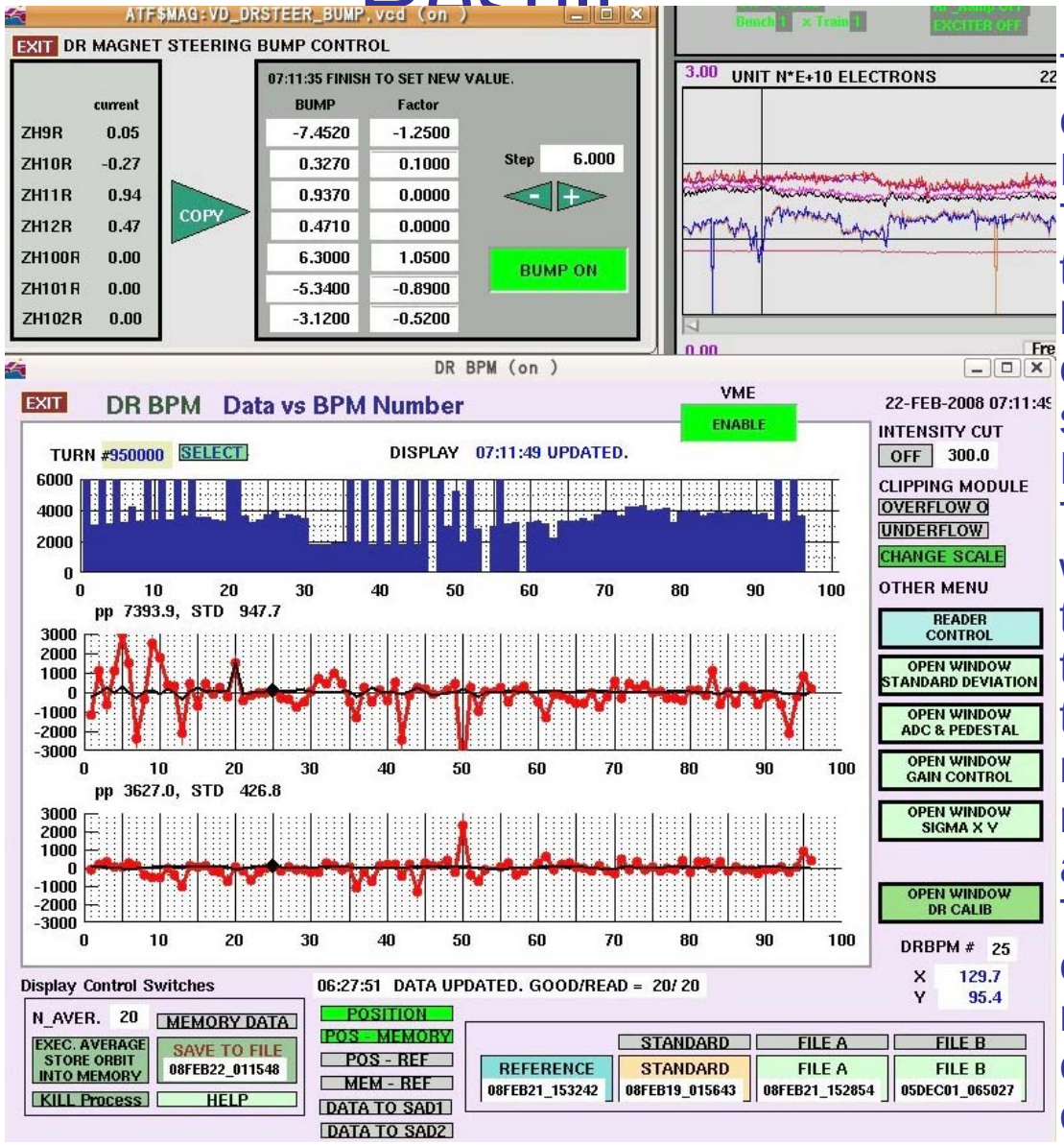
S.Kuroda

Power Supply Control for the Pulse Bump

The pulse current control, which is synchronized with the beam injection, is required for the steering magnets of the local bump orbit to keep a stable beam condition.



Bump Orbit Test Result



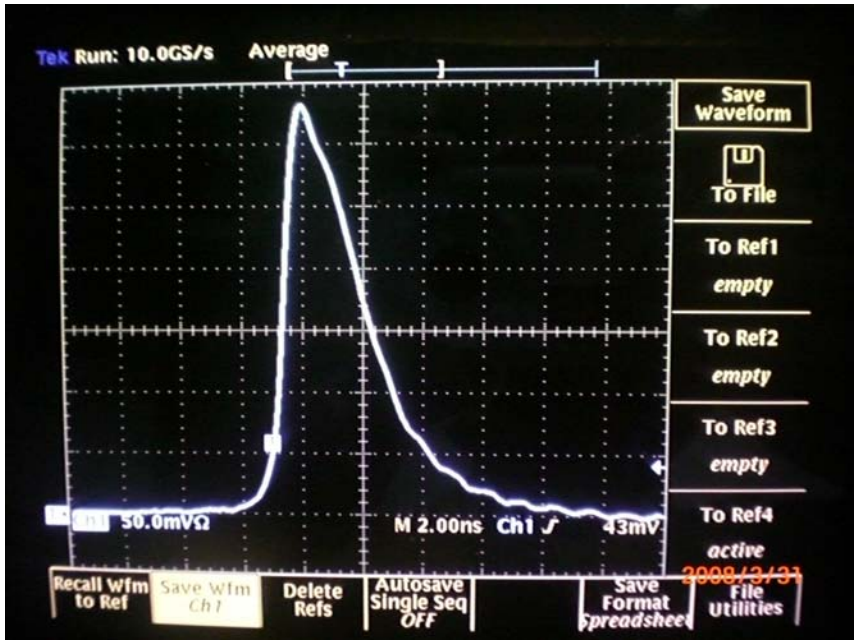
The height of the bump was confirmed by the displacement at BM20 and the magnet currents.

There is no BPM at the location of the peak of the bump. BPM20 is located 1m downstream of the peak of the bump. The calculation was shown 2mm displacement at the BPM20.

The picture shows the control window and the beam position of the damping ring. The black line in the horizontal beam position shows the displacement by the bump magnet from the COD. The measurement results showed good agreement with the calculation.

The dispersion correction was not enough at this condition. There was no beam blow up for the vertical emittance and no beam loss in this experiment.

Pulse source(FID FPG 10-6000KN)



Specification

Maximum output voltage + 10 kV

- 10 kV

Rise time @ 10-90% level - < 1 ns

Rise time @ 5-95% level - < 1,2 ns

Pulse duration @ 90% - 0,2-0,3 ns

Pulse duration @ 50% - 1,5-2 ns

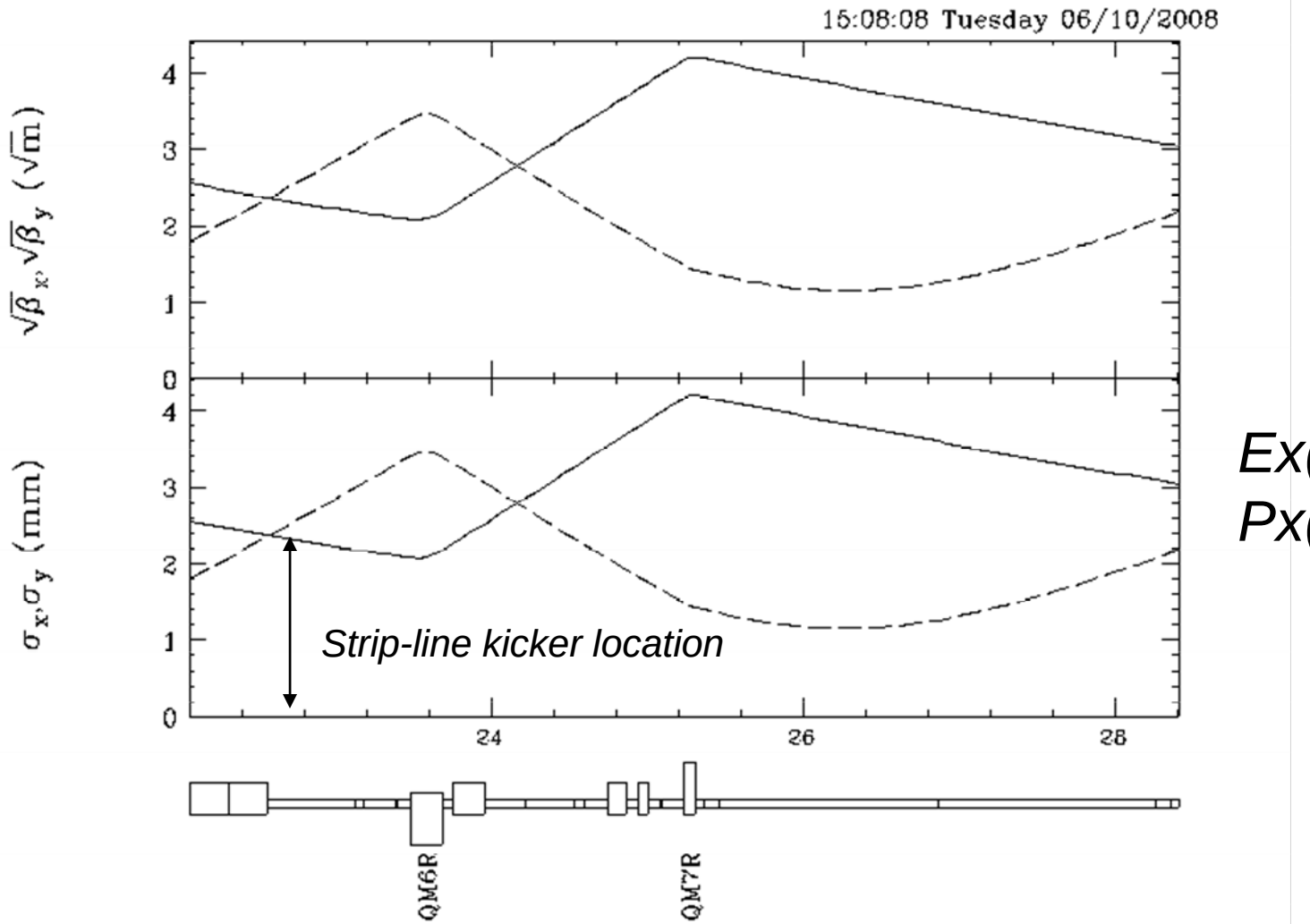
Output pulse amplitude stability - 0,5-0,7%

Maximum PRF in burst - 6,5 MHz

Number of pulses in burst - up to 110

PRF of bursts - up to 5 Hz

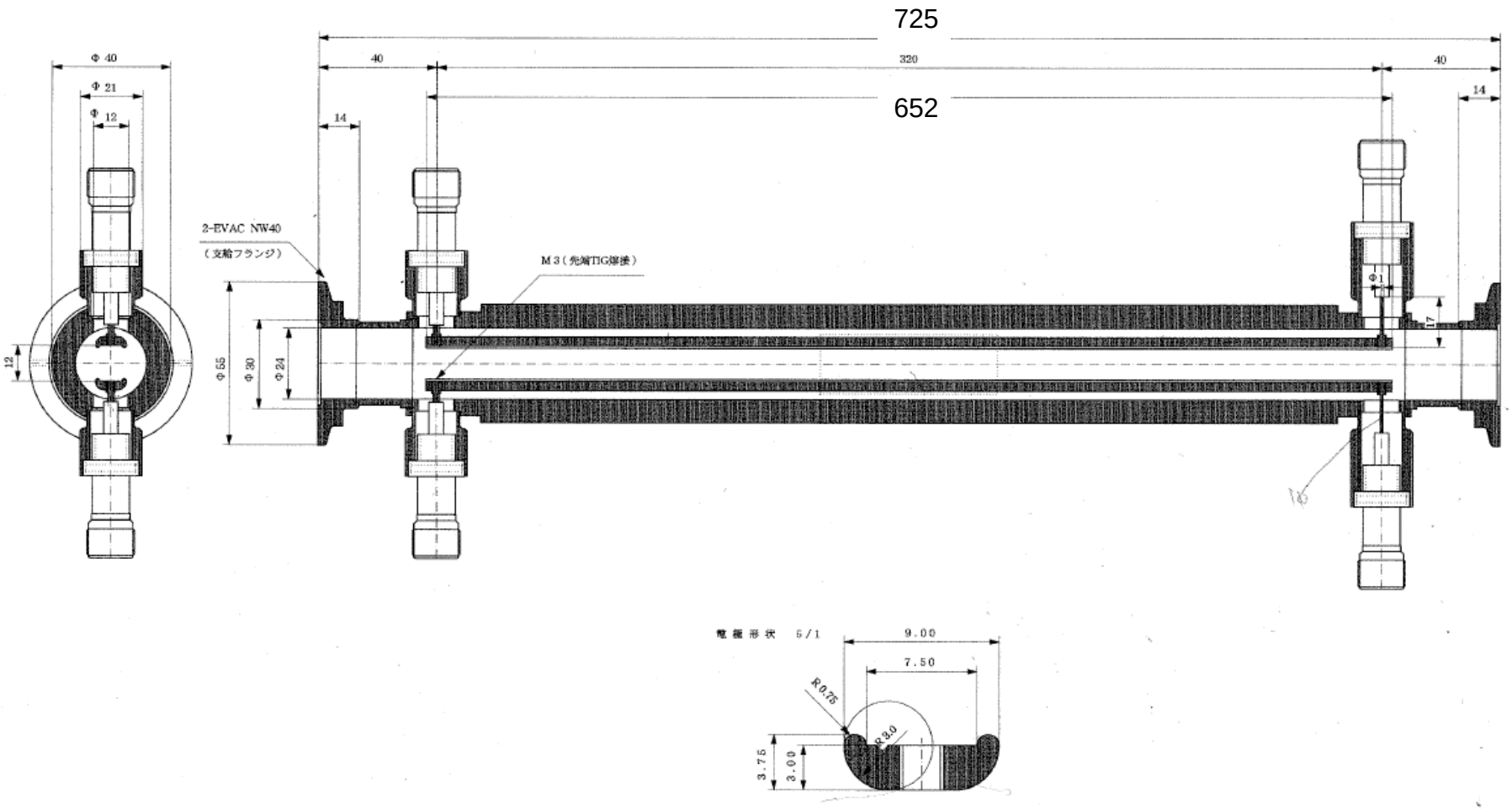
Aperture



Ex(inj.)=1e-6,
Px(inj.)=1e-2

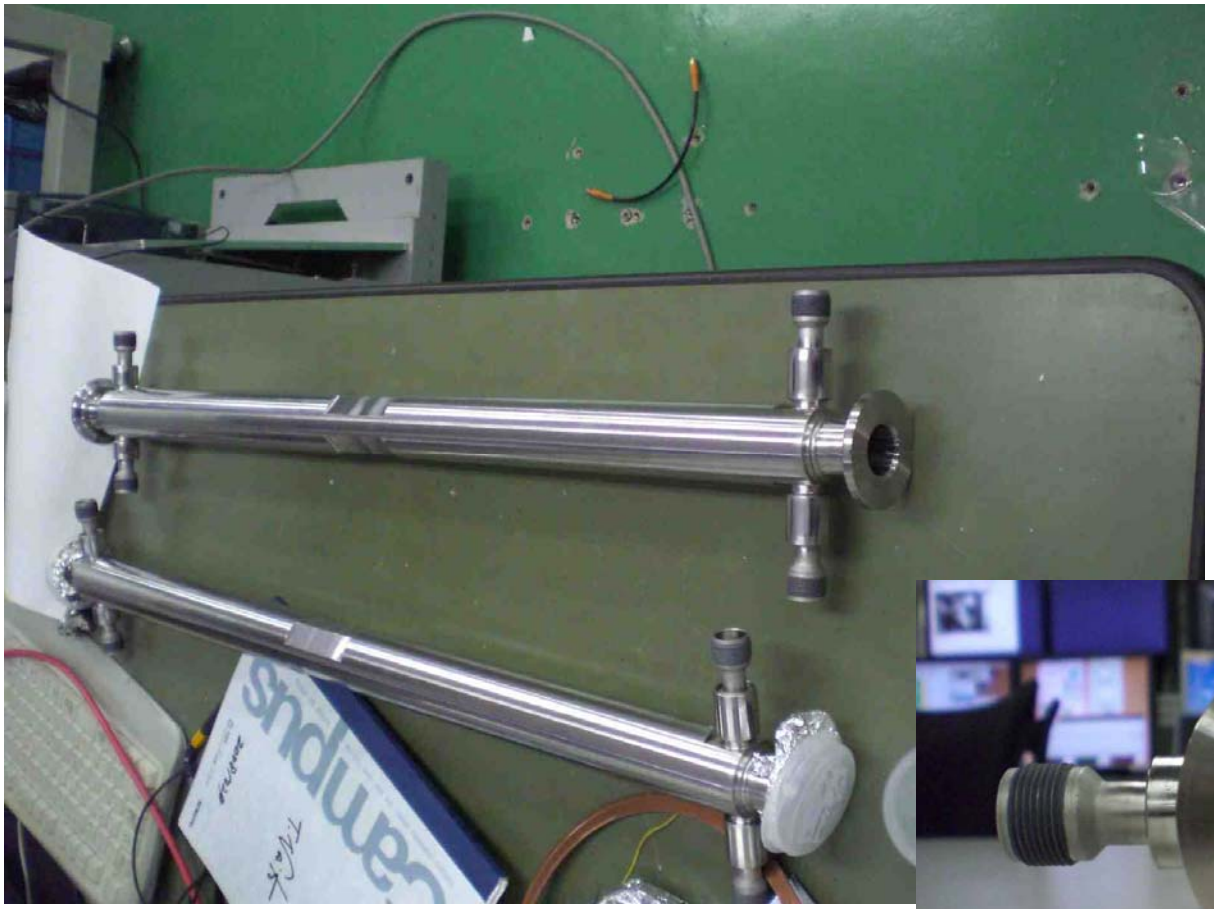
Horizontal aperture is limited by the strip-line electrode. 3σ of the injection beam can get through a 12mm gap of the strip-line kicker section.

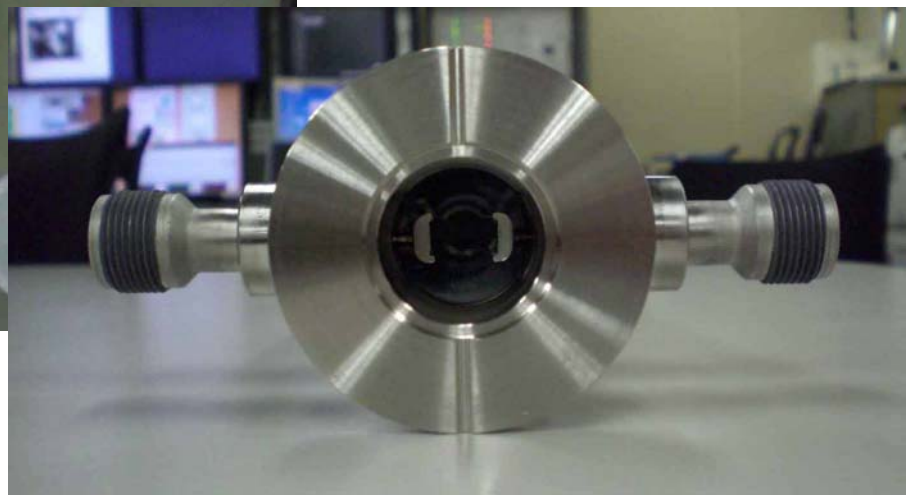
Proto type strip-line kicker(60cm long)



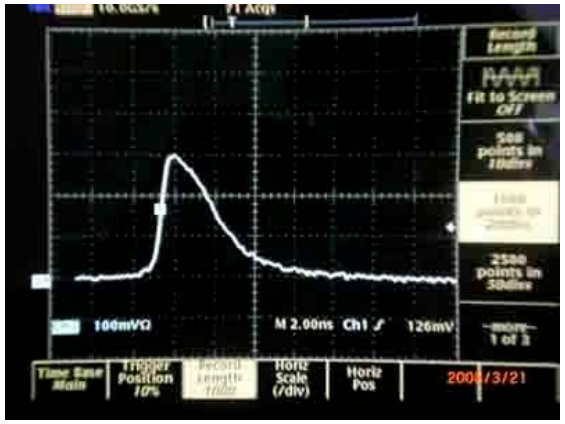
KEK fabricated a proto type 60cm long strip-line kicker, which has a 12mm electrode gap. The input/output connectors are HN-type commercial available feed-through.

Photo of the fabricated strip-line kicker

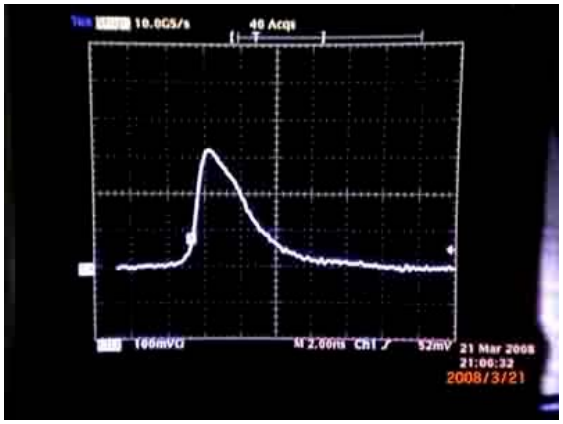




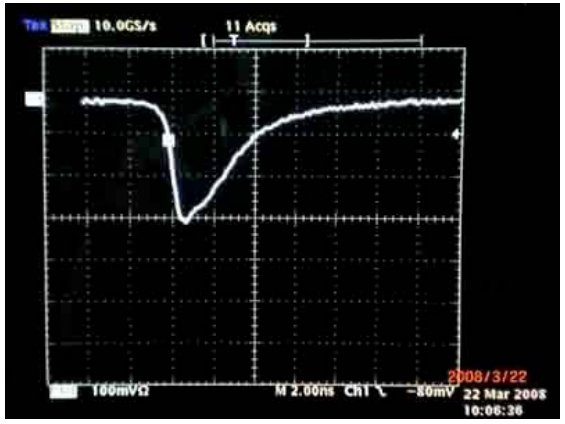
10kV pulse apply to the strip-line



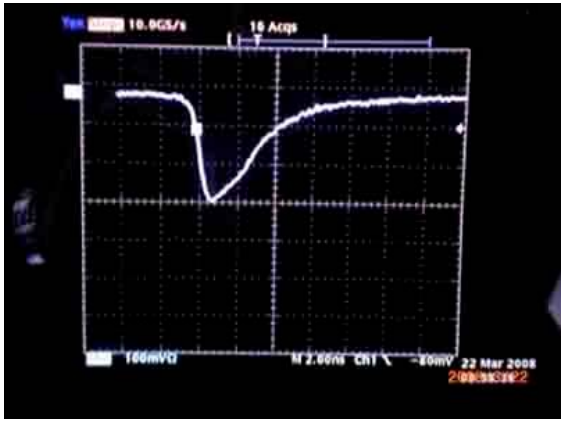
Pulser output(pos) 9.7kV peak



Strip-line output(pos)



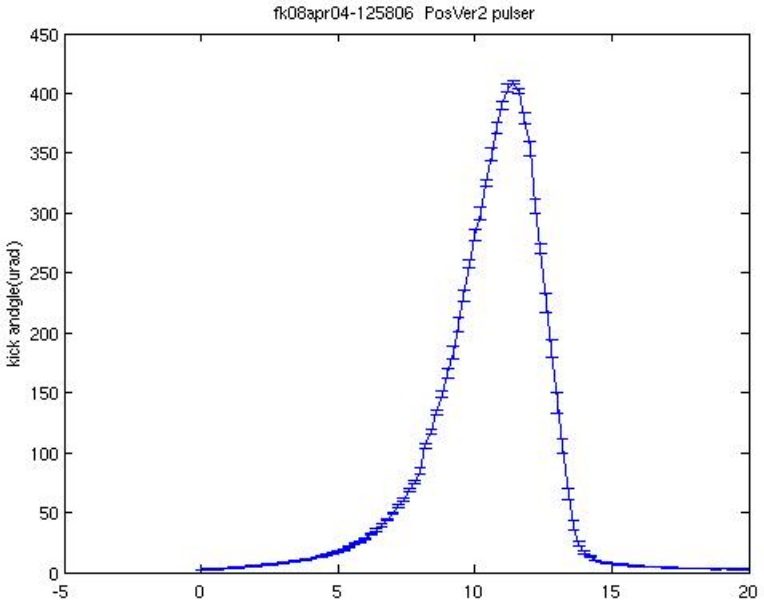
Pulser output(neg) 8.5kV peak

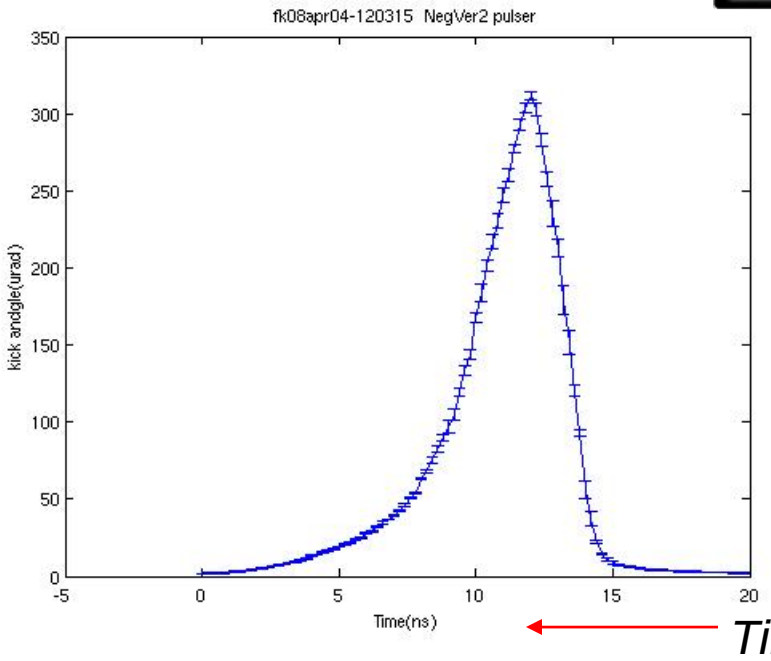


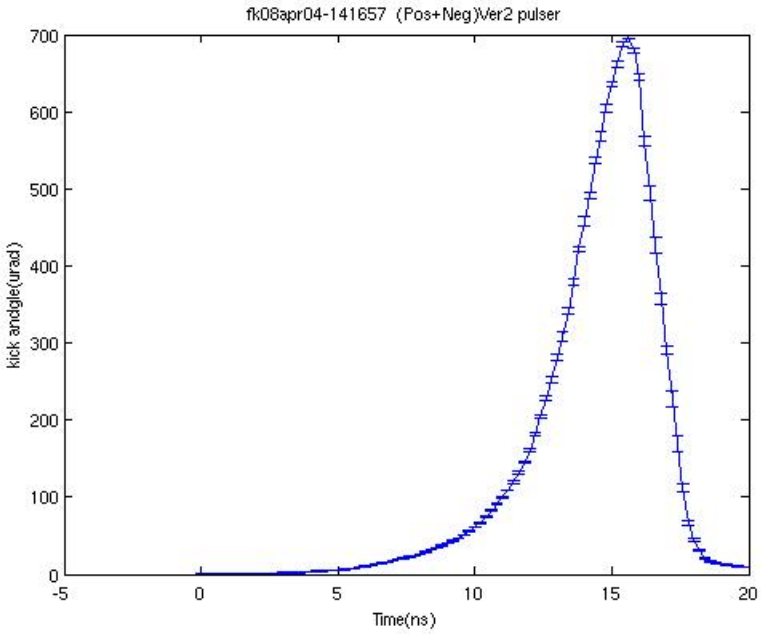
Strip-line output(neg)

A 10kV pulse could be applied for each electrode without any deterioration to the waveform of the pulser, which means no-discharge at the connectors and the electrodes.

Beam kick profile from the beam oscillation amplitude

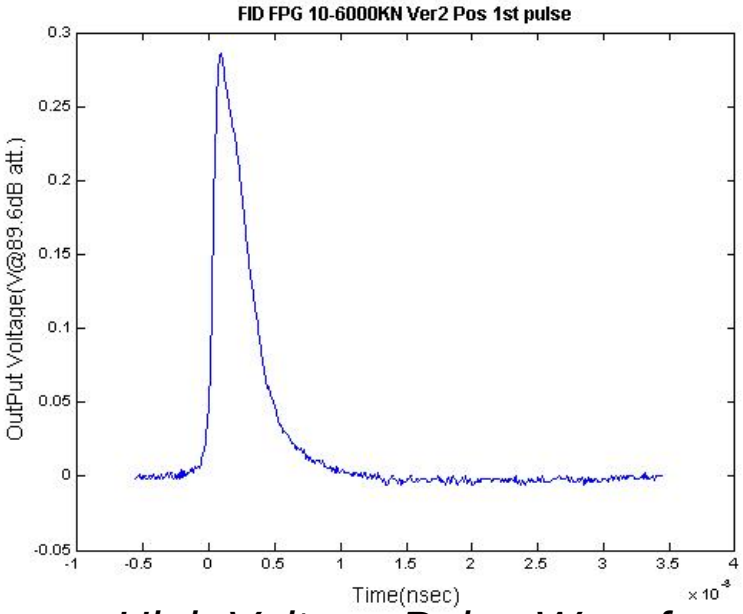




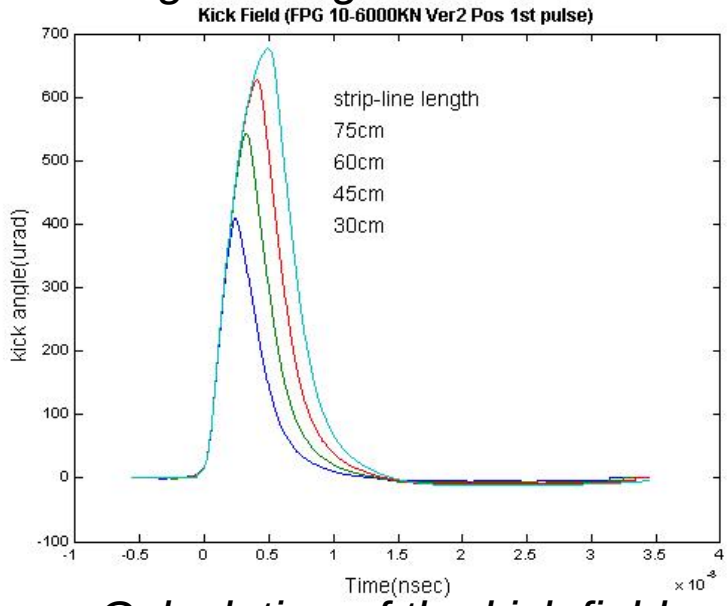


Beam kick test in the DR was carried out. The pictures show the timing scan of the kick pulses for the beam timing in the cases of the Positive, Negative and Pos+Neg pulses. The peak kick angles are 0.4, 0.3 and 0.7mrad, respectively, which agreeds with the estimation from the kick voltage and the strip-line dimensions.

Estimation of kick angle



High Voltage Pulse Waveform

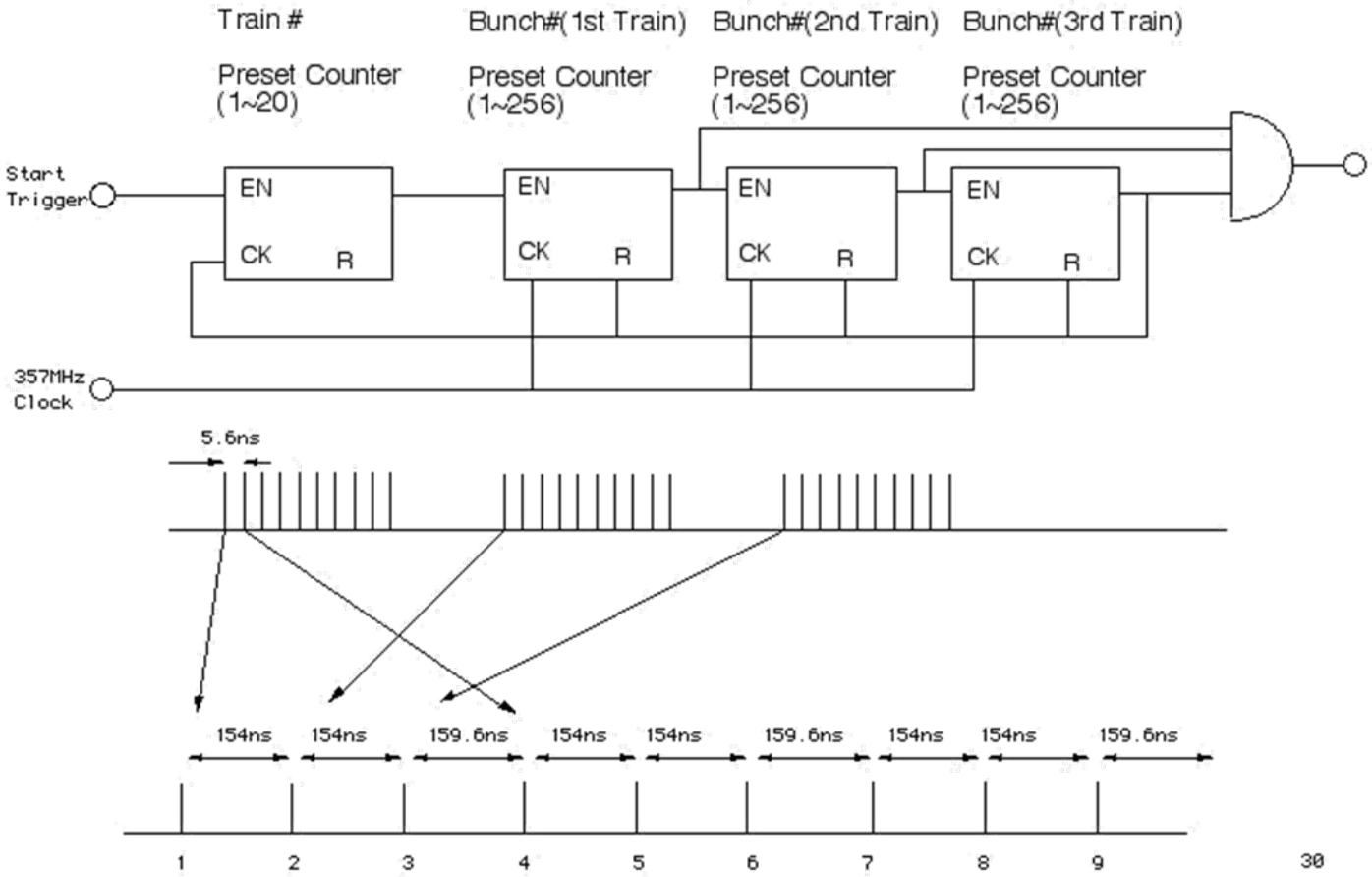


Calculation of the kick field

When a high voltage pulse(upper picture) is applied to the different length of the strip-line, the waveform of the kick field and the kick angle are calculated. The kick angle is calibrated from the result of the beam kick test in DR.

In the case of a 60cm long strip-line, the kick angle is 0.6mrad and the rise time is less than 5ns. When a pair of pulsers(positive/negative) for each strip-line and two unit of 60cm long strip-lines are used, the total kick angle will be 2.4mrad.

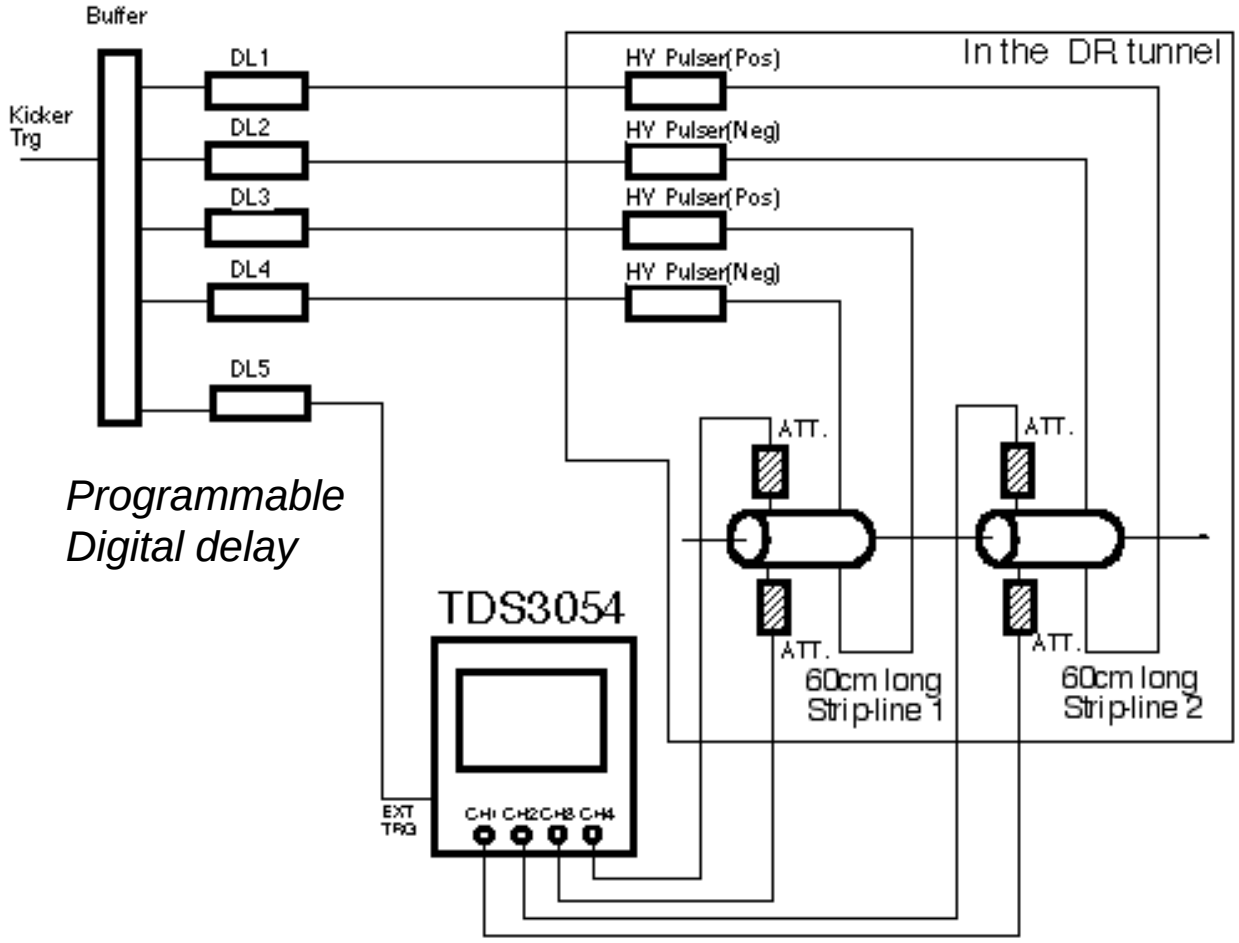
Pulse train generator



Special timings of pulses are required for the strip-line kicker, when extract the multi-bunch beam from the DR. The pulse timing needs to shift one bunch spacing every three pulses interval. The fabrication of the pulse train generator was completed.

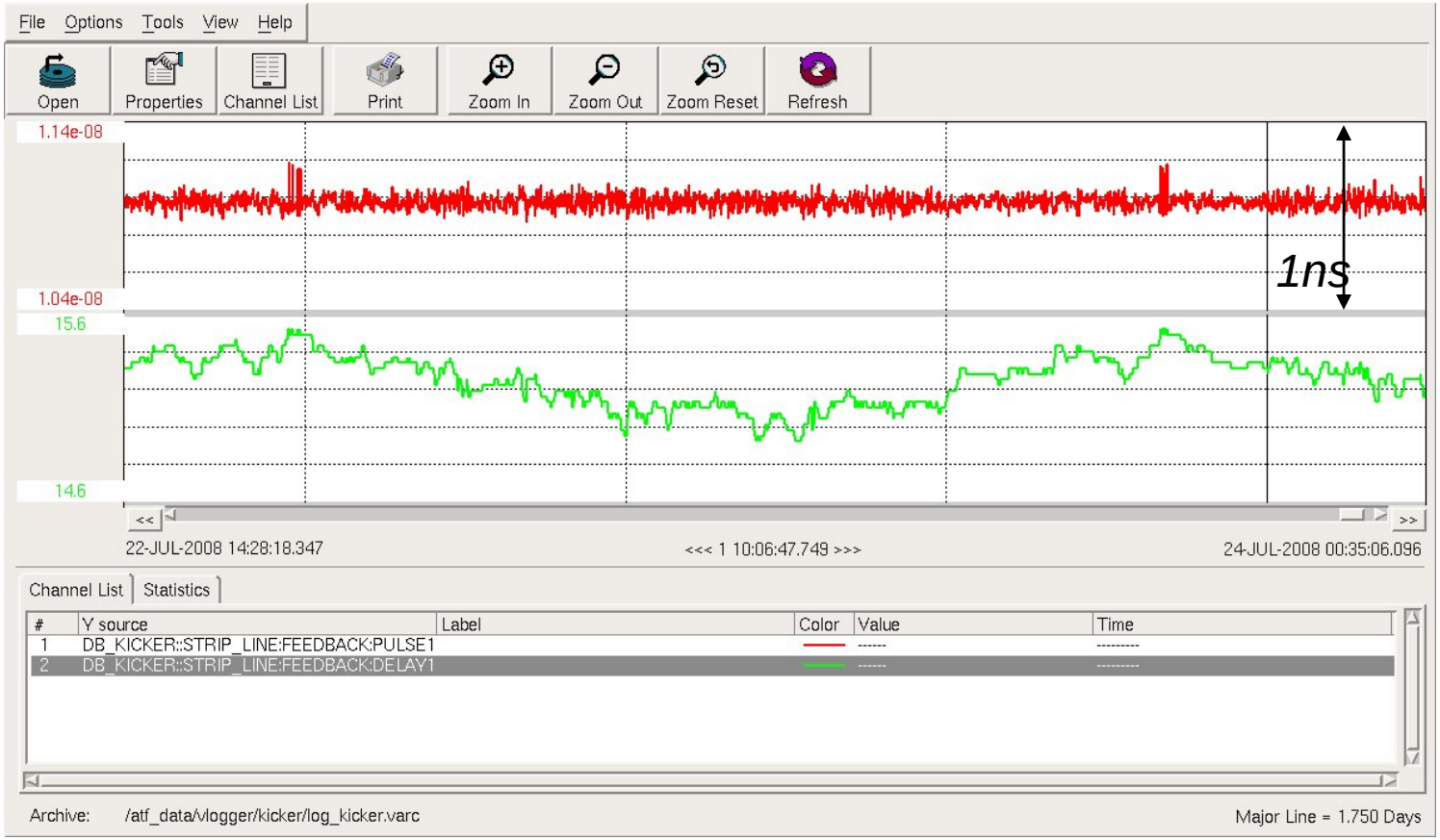
Trigger timing FB for Strip-line kicker

20080115 T.Naito



Precise triggers for each pulser and the timing control is required. The pulse measurement using oscilo-scope and the timing control by digital delays comprises the trigger timing feedback. The step of the digital delay is 60ps. The trigger system could keep the pulse timing in the range of 100ps.

Timing drift and the FB result

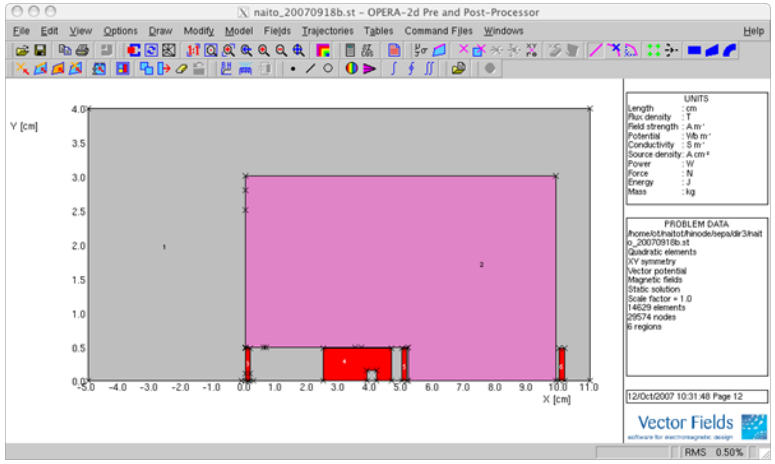


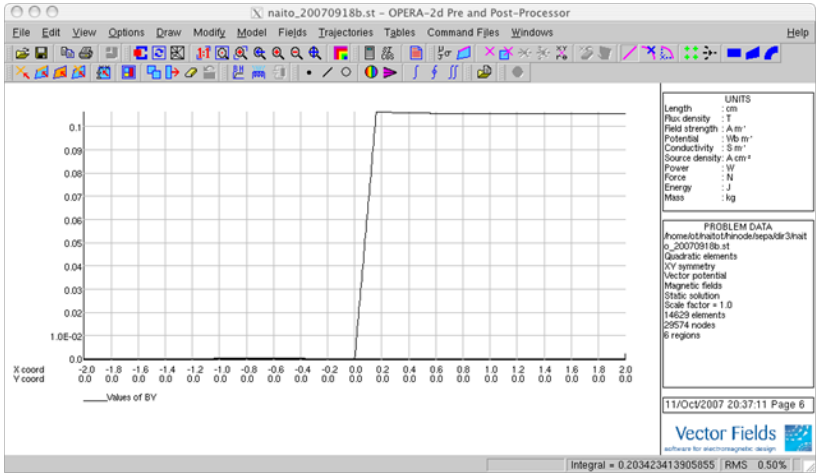
Measurement

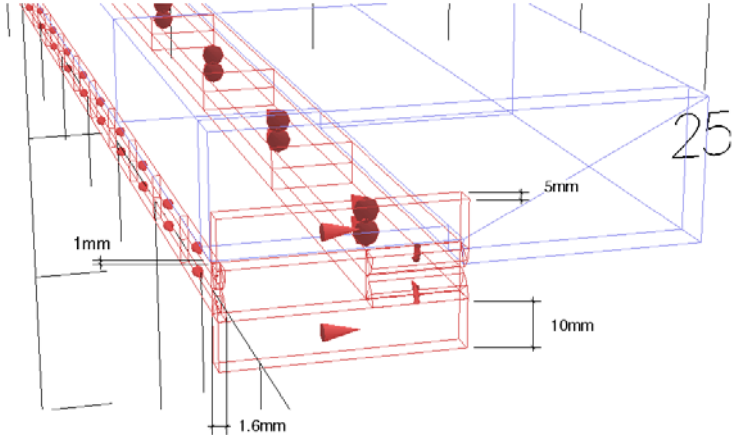
Delay Setting

The graph shows the pulse timing measurement and the delay setting of the feedback system. The pulser output drifted about 600ps in a day, which is compensated to less than 200ps except for a bit error in the delay module.

Auxiliary septum magnet design and fabrication





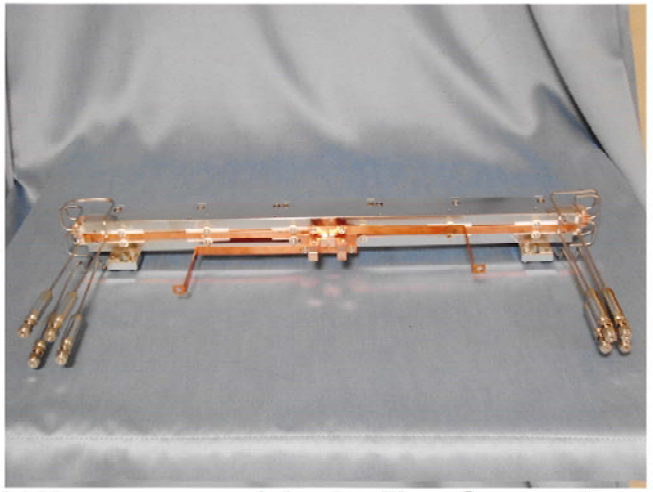


The design work of the auxiliary septum magnet was carried out by using OPER 2D and 3D.

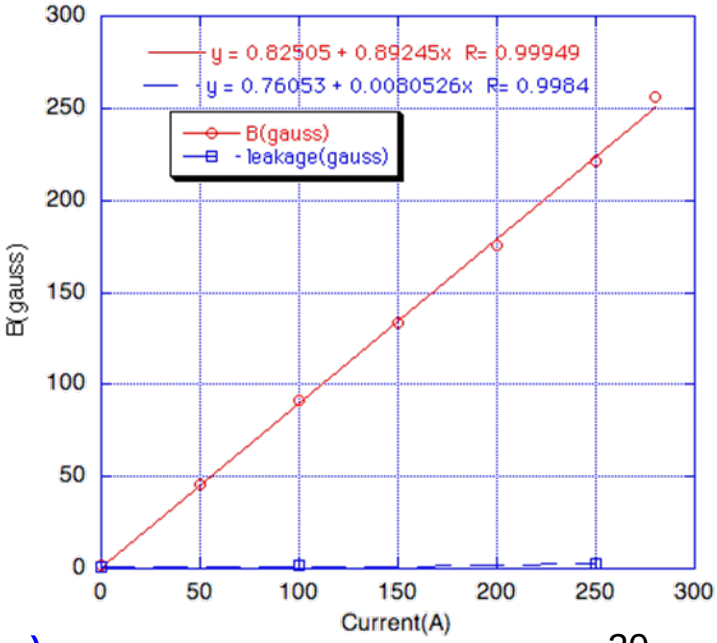
The designed auxiliary septum magnet has 1.6mm of a thin separator and 0.1T of bending field.

Auxiliary septum magnet

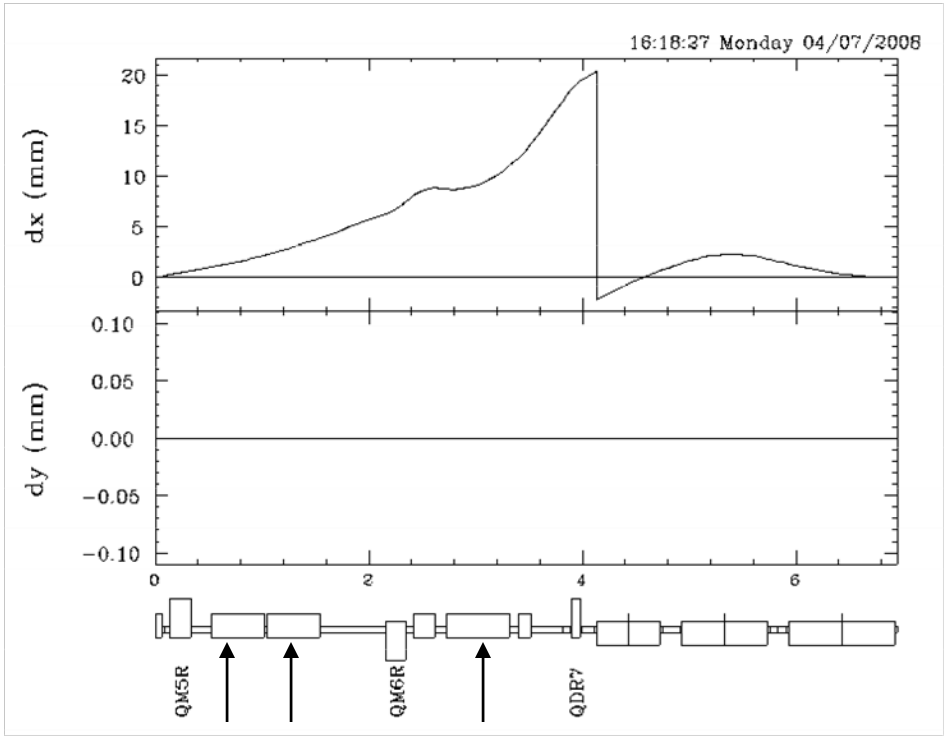
The current is applied up to 300A without any temperature problem. The leakage flax is less than 1%, which can be compensated by the auxiliary coil.



Feild Measurement of the Auxiliary Septum Magnet



EXT Orbit with Fast Kicker *S.Kuroda*



Fast Kicker BSAUX

Fast Kicker Strength: 1mrad X 2

Correctors K0: ZH9R -0.002320433716
ZH100R 0.009876184722
ZH101R -0.005210348744

Free parameters; K0 of BSAUX, BS1-3X

Imposed Condition;

Abs[dx]< 3 mm in BS1-3X region

dx=dpx=0 at the end of BS3X

Results;

BSAUX K0=-.010280163677

BS1X K0 =.0011826626821

BS2X K0 =.0031361169236

BS3X K0 =-.0013134448462

BS1&2X is weaker by 8.4%, BS3X is stronger by 1.1%.

Orbit is measured from DR design orbit
+ toward EXT

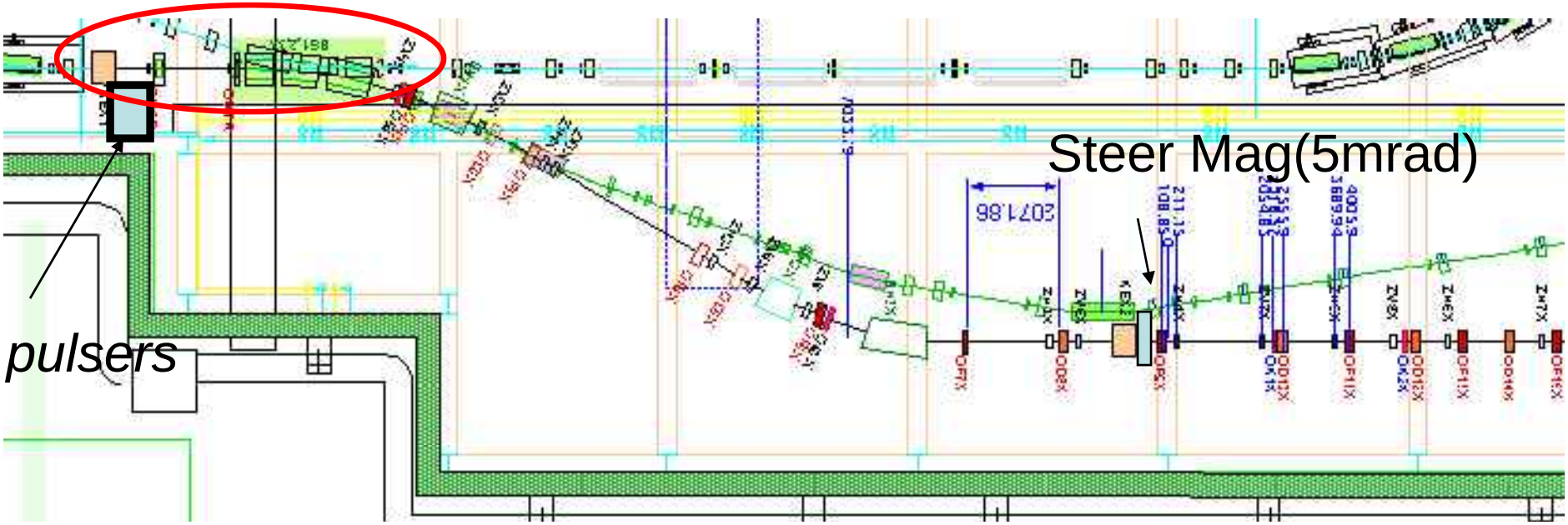
Orbit is measured from EXT design orbit
- toward DR

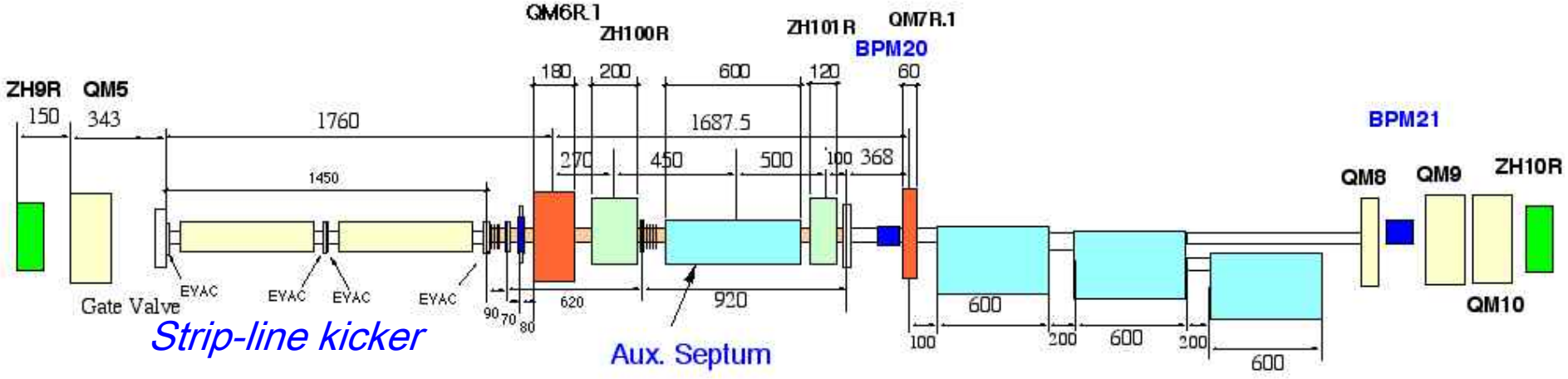
Physical aperture in septum region must be larger than 3mm+orbit distortion(+beam size)

2009/4/18

Installation of the components at the machine time in January

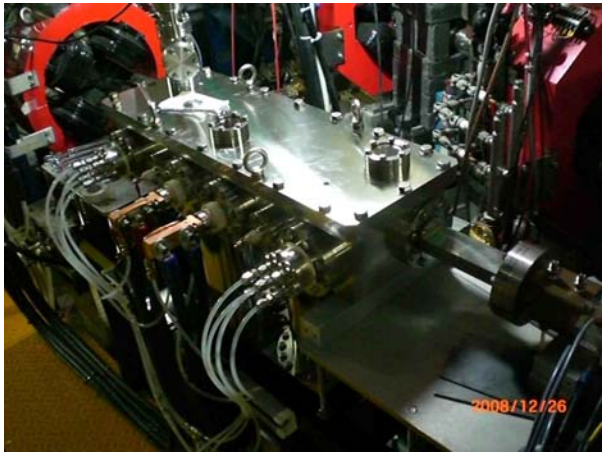
2009/01/13~23



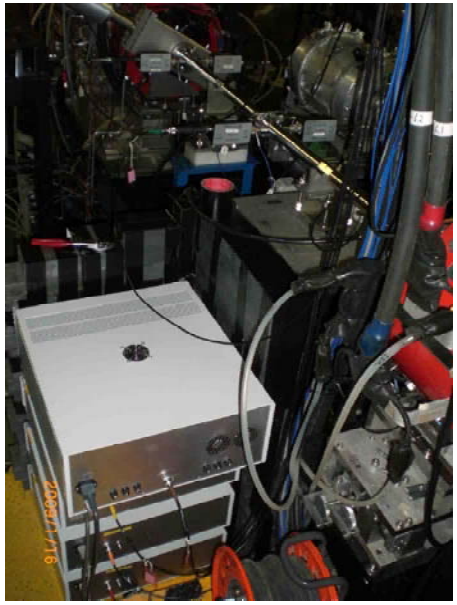


Pictures of installed components

Strip-line electrodes



Aux. Septum



FDI pulsers

Bump PS and Septum PS

Trouble of the pulsers

The beam test in January was stopped due to the pulser trouble. Two of four pulsers broke down just after one hour from turned on the pulsers, when the beam storage condition. We suspect that the trouble come from the high radiation environment and the high current condition in the semiconductors due to followning reasons,

•LLNL pulser was also tested at the same location, it was also broken after one hour from turned on the pulser.

•The radiation level at the location of the pulser was very high, over10msv/h(gamma) and 100micro sv/h(neutron).

•There was no trouble at the experiment of the south straight section, where was low radiation area. The FID pulser operated over one week and the location was just below the beam line.

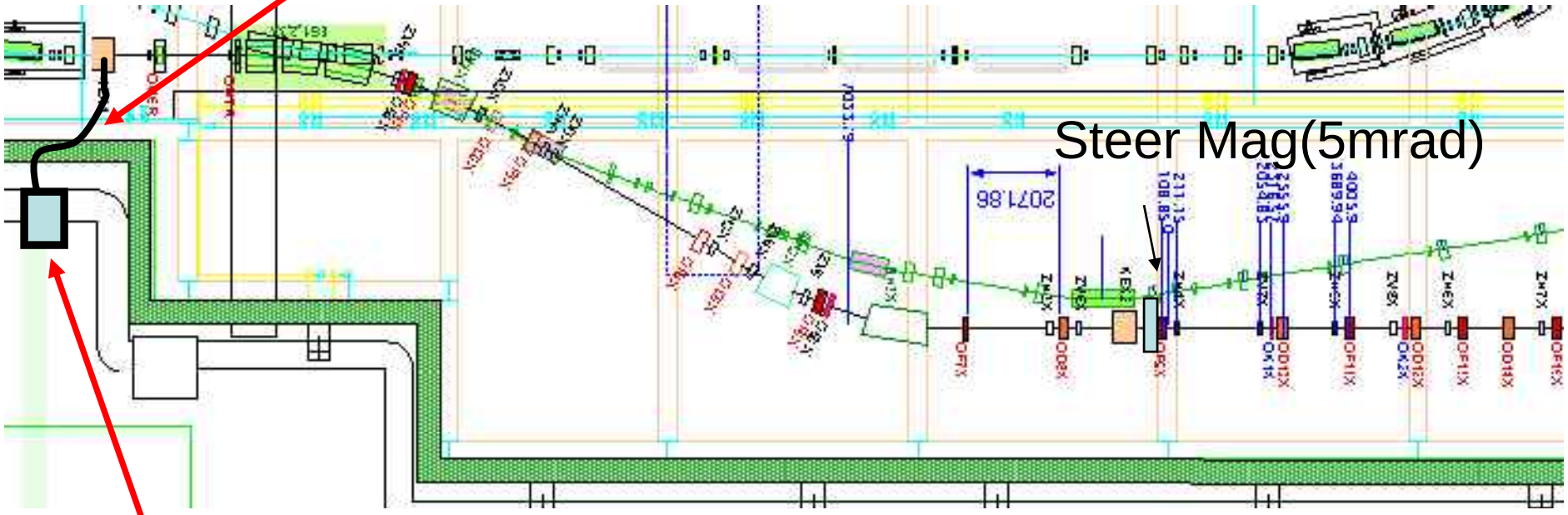
The troubled pulsers were sent back to FID Co., they reported that the FET of the drive circuit was broken, it not the DSRD device. It agree with the expectation of the radiation damage of ON device, which means high current flow the semiconductor.

From the result, we decided to locate the pulser outside of the shielding.

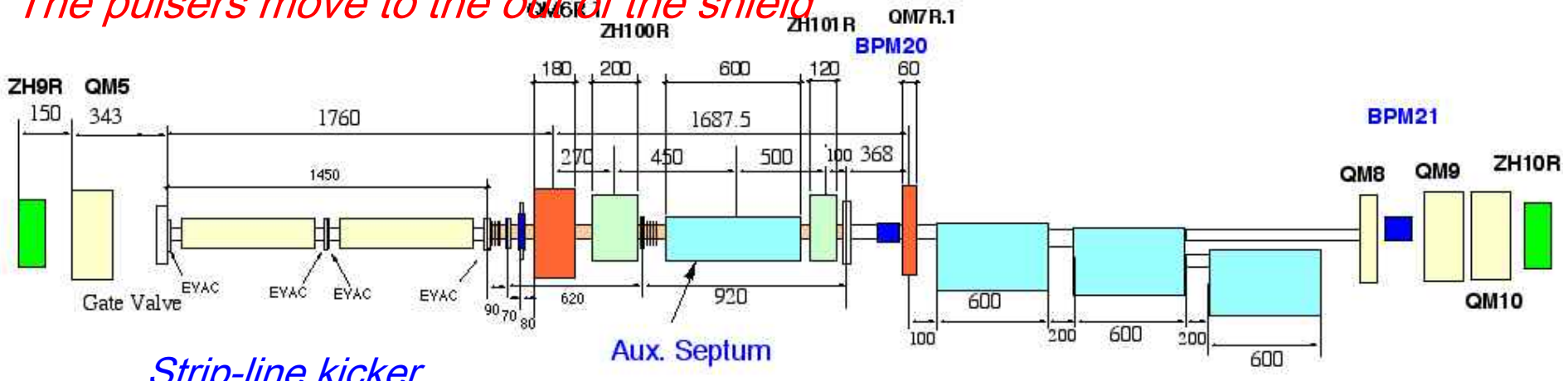
New location plan of the pulsers

6m cables

2009/06/01~12

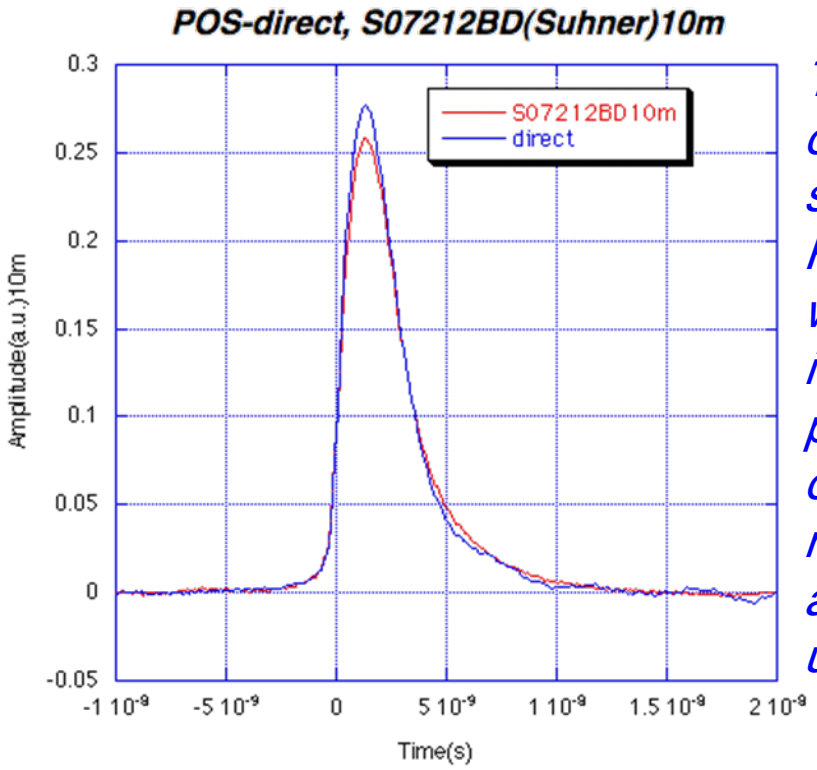


The pulsers move to the out of the shield



Strip-line kicker

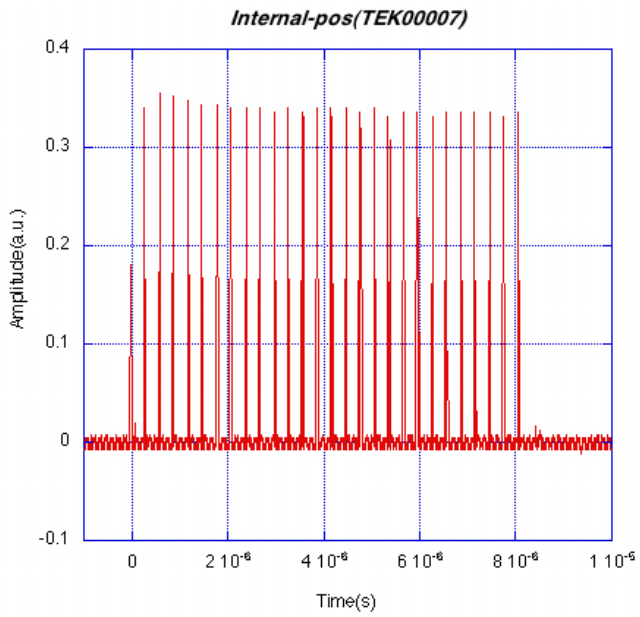
Waveform with 10m long cable

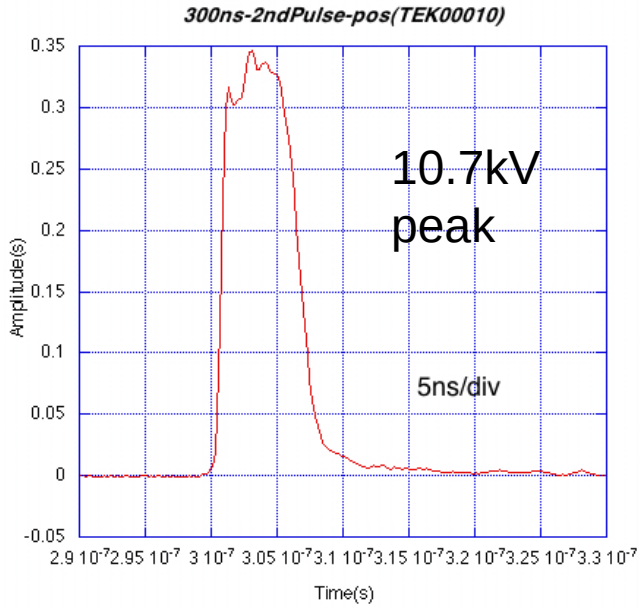


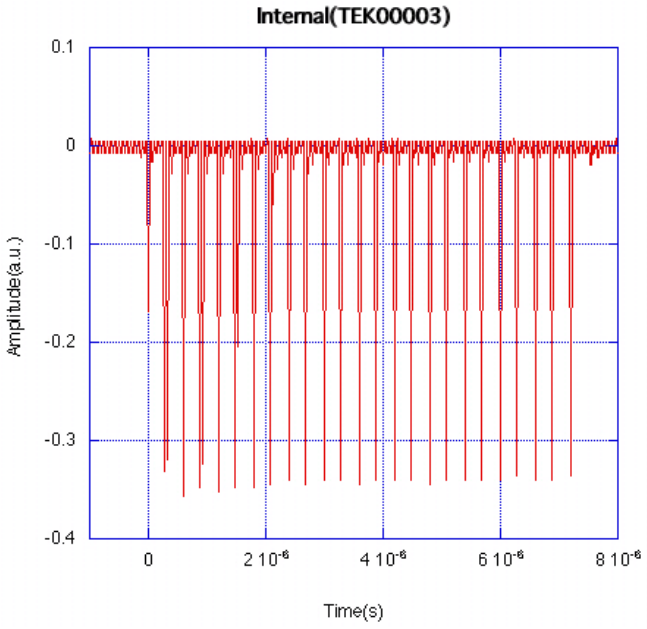
The pulse transmission characteristics was checked to locate the pulser out of the shielding.

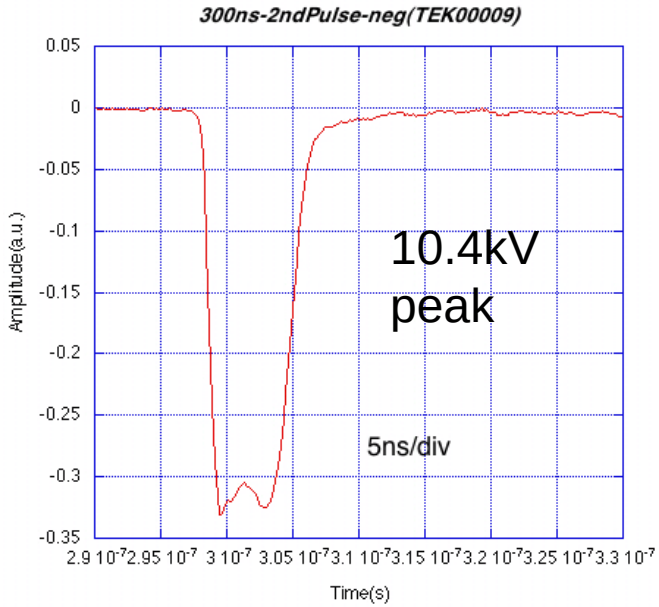
Picture shows the comparison of the waveform with and w/o 10m long cable. There is no deterioration for the rise time of the pulse, the amplitude loss was several, which came from the voltage drop in the cable. The minimum distance of the cable is 6m long, the amplitude loss can be reduced to half when use a 6m long cable.

10kV, 4ns pulser



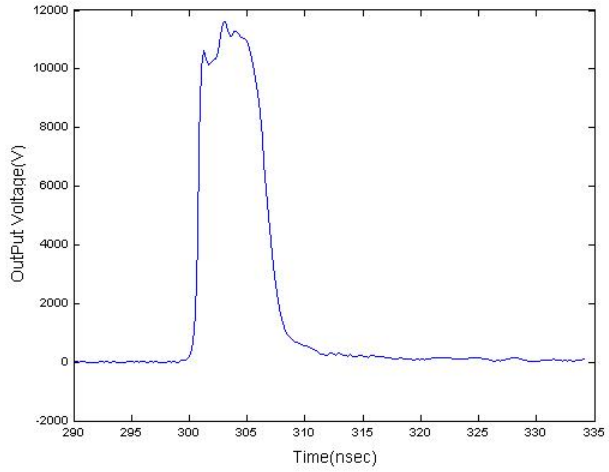


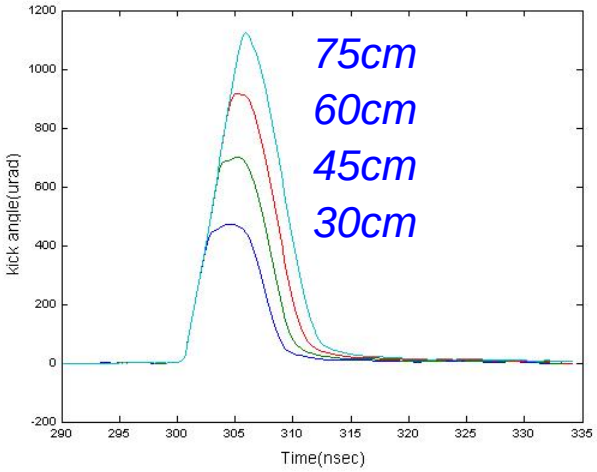




To increase the kick angle, we ordered 4ns pulse width pulsers to FID. The rise time and the pulse width is ok for our application. The flatness of the pulse train is defined from 7th pulse to 37th pulse.

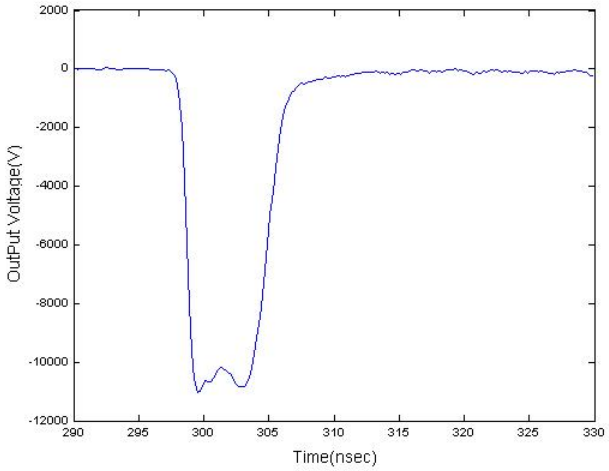
Kick angle estimation of the 4ns pulser



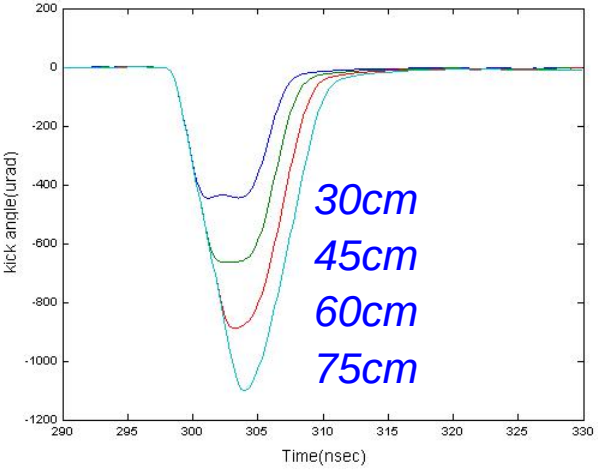


The kick angle of the 4ns pulser will be 0.9mrad in the case of 60cm long strip-line. The total kick angle of two pairs of the strip-line is 3.6mrad, which will be able to extract the beam without the auxiliary septum magnet.

Pulse waveforms



Estimated kick angles



Beam Test Schedule

Next beam experiment is scheduled in June.

Two weeks for the fast kicker test is required, one week for the vacuum work and one week for the beam time.

- *Beam storage to DR 1 day*
- *Local bump orbit check 1 day*
- *Beam kick by strip-line kicker 5 days timing scan, septum orbit, etc,*
- *Three train extraction*
- *Stability measurement 2days*