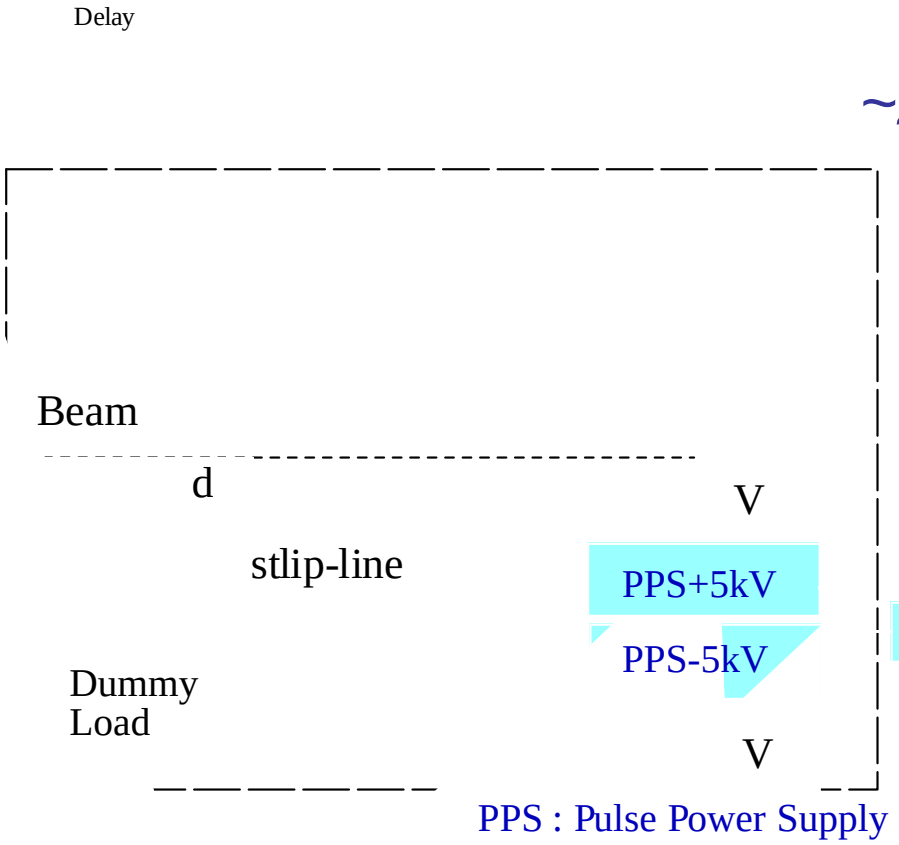
Fast Kicker status & plan

T.Naito(KEK)

7th TB/SGC meeting
17Dec2008

Multi-units Strip-line Kicker for ILC-DR



~20 units for 0.6mrad kick angle

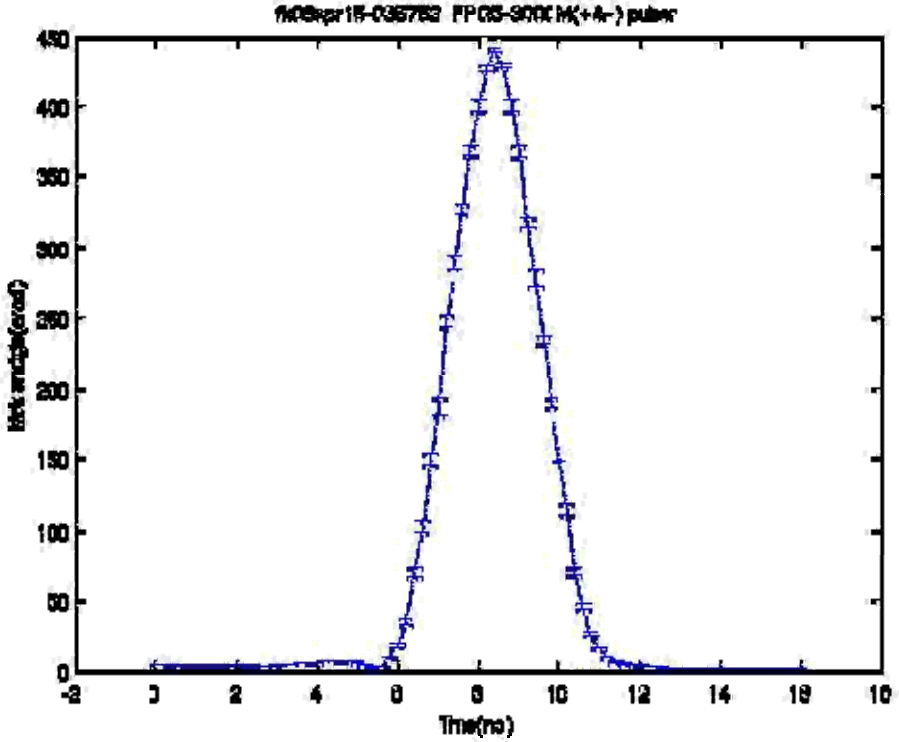
$$\Delta\theta = 2g\frac{eV}{E}\frac{L}{d}$$

L = *strip – line length*
d = *distance between the electrodes*
V = *pulse voltage*
E = *Beam energy*

$$g = \tanh\left(\frac{\pi\omega}{2d}\right)$$

ω = *strip – line width*
d = *distance between the electrodes*

Beam kick profile with 5kV FID pulsers and a 30cm long strip-line

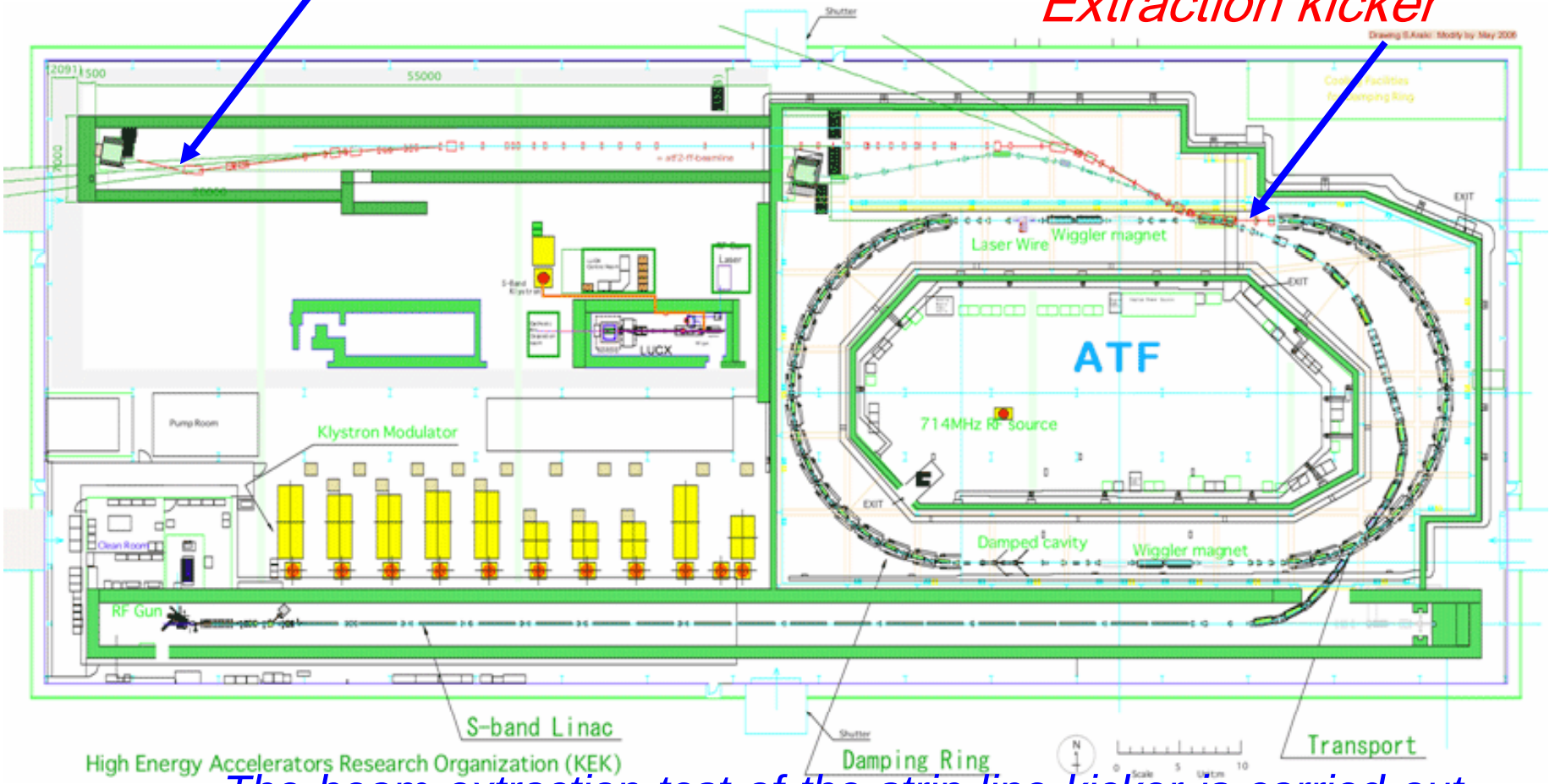


The beam kick test in the DR had been carried out by using a 30cm strip-line and a pair of 5kV FID pulsers. The picture shows the timing scan of the kick pulse to the beam, when the Positive and Negative pulses(5kV) are applied at the same timing. The peak kick angle is 0.44mrad and the rise time of the kick field is 3ns, which agreed with the estimation from the kick voltage and the strip-line dimensions.

Experiment at ATF2

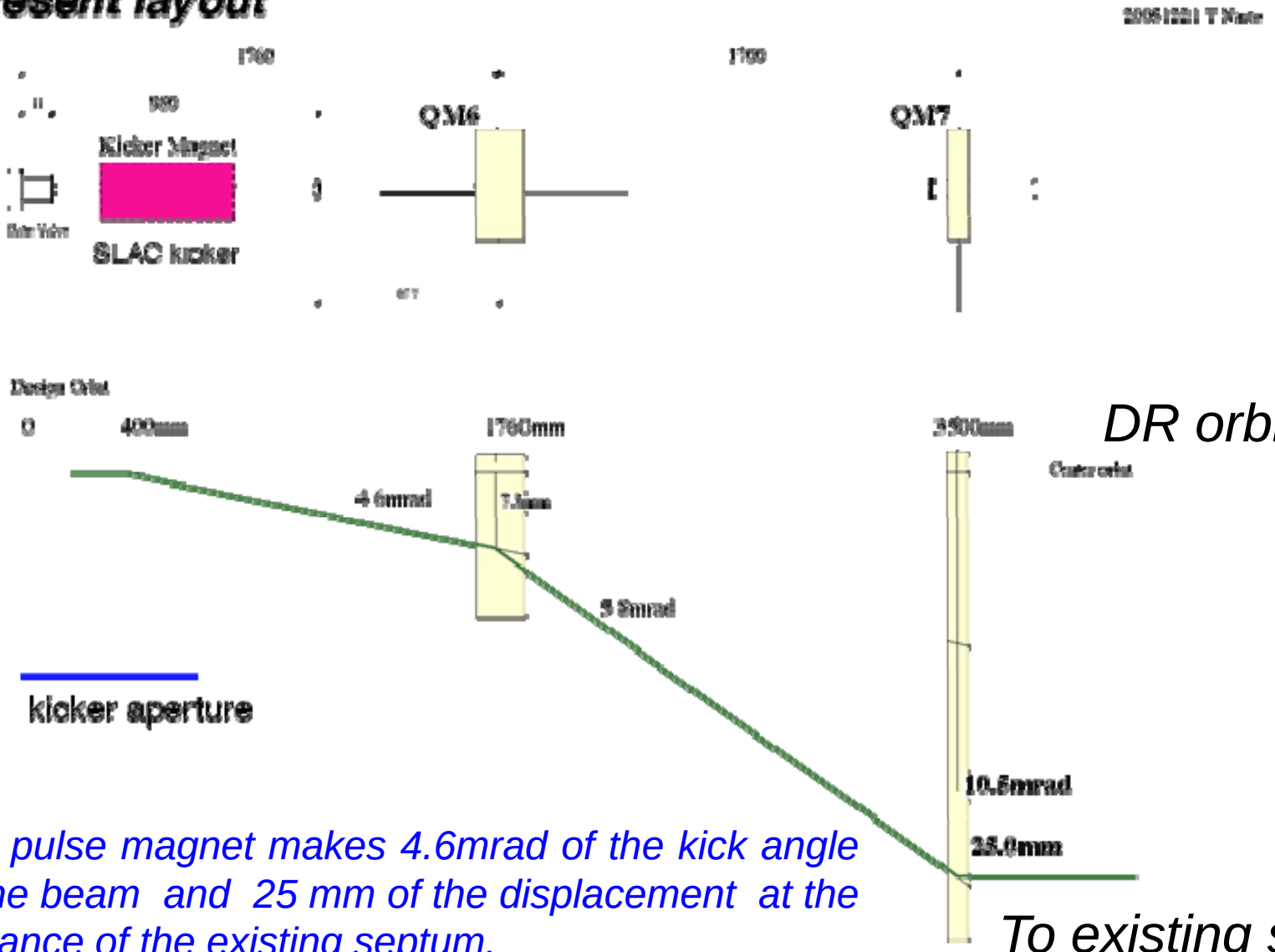
ATF2 - 40nm beam production, measurement

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

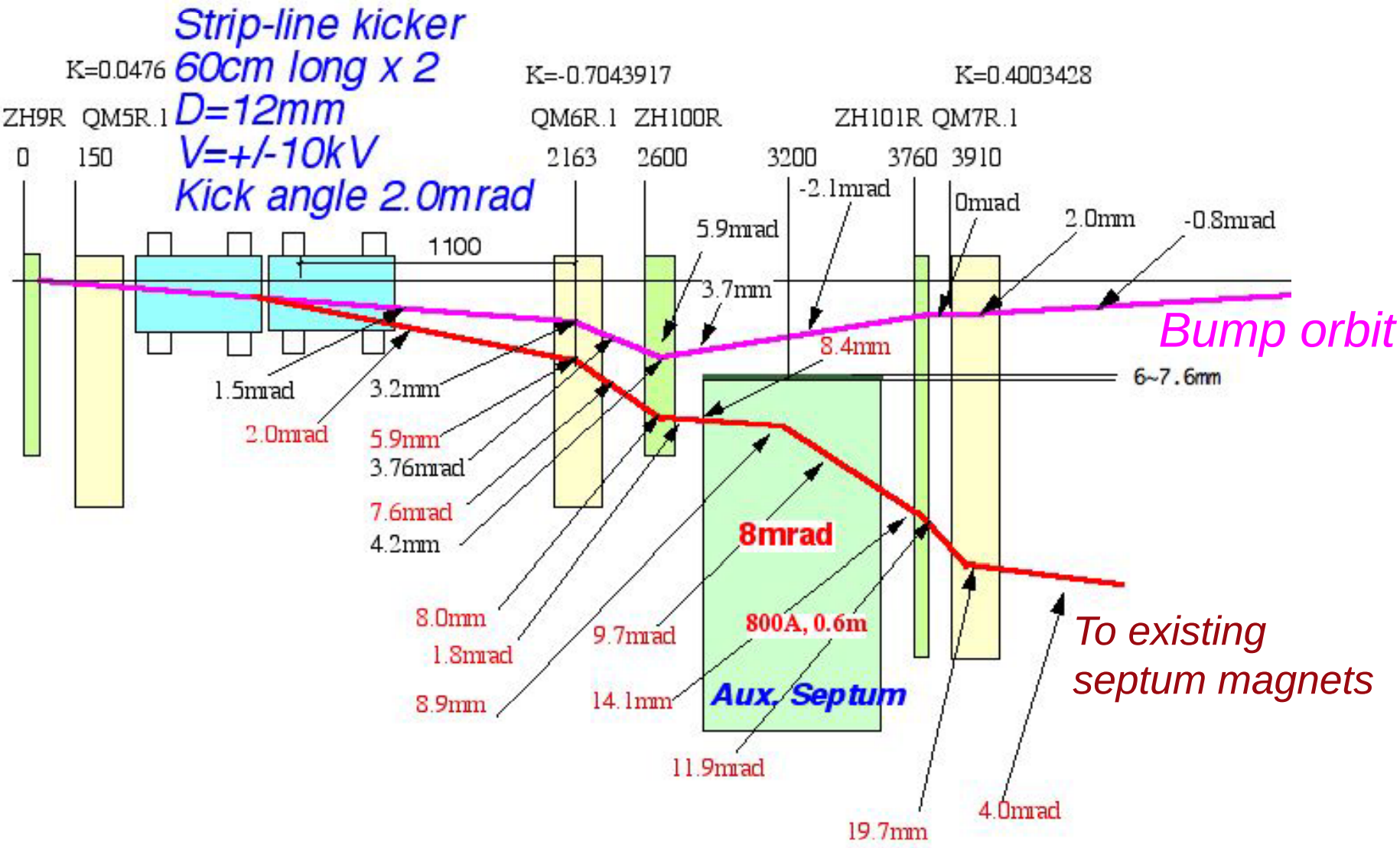


DR orbit

To existing septum magnets

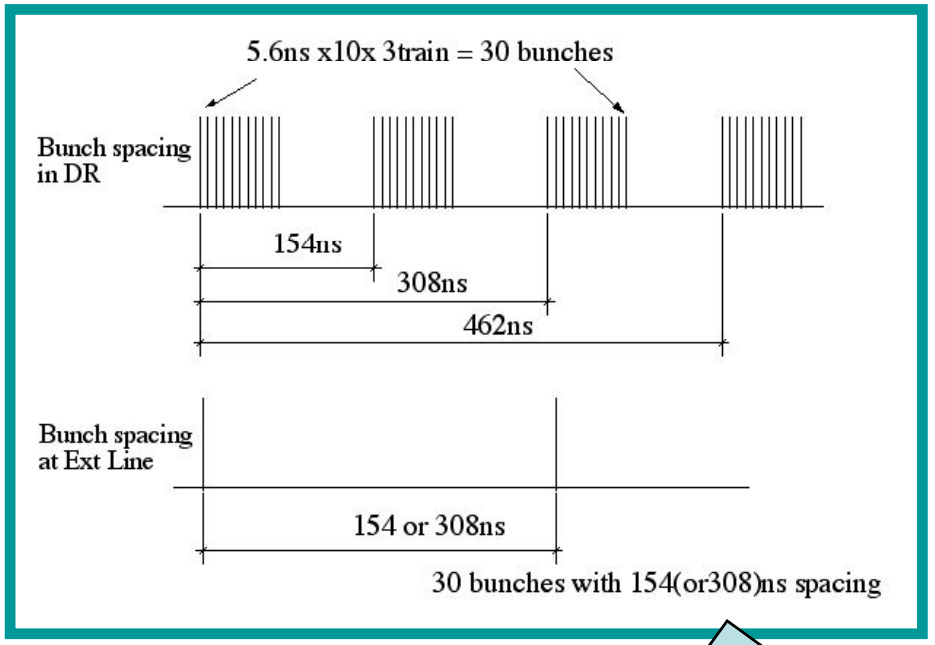
The pulse magnet makes 4.6mrad of the kick angle to the beam and 25 mm of the displacement at the entrance of the existing septum.

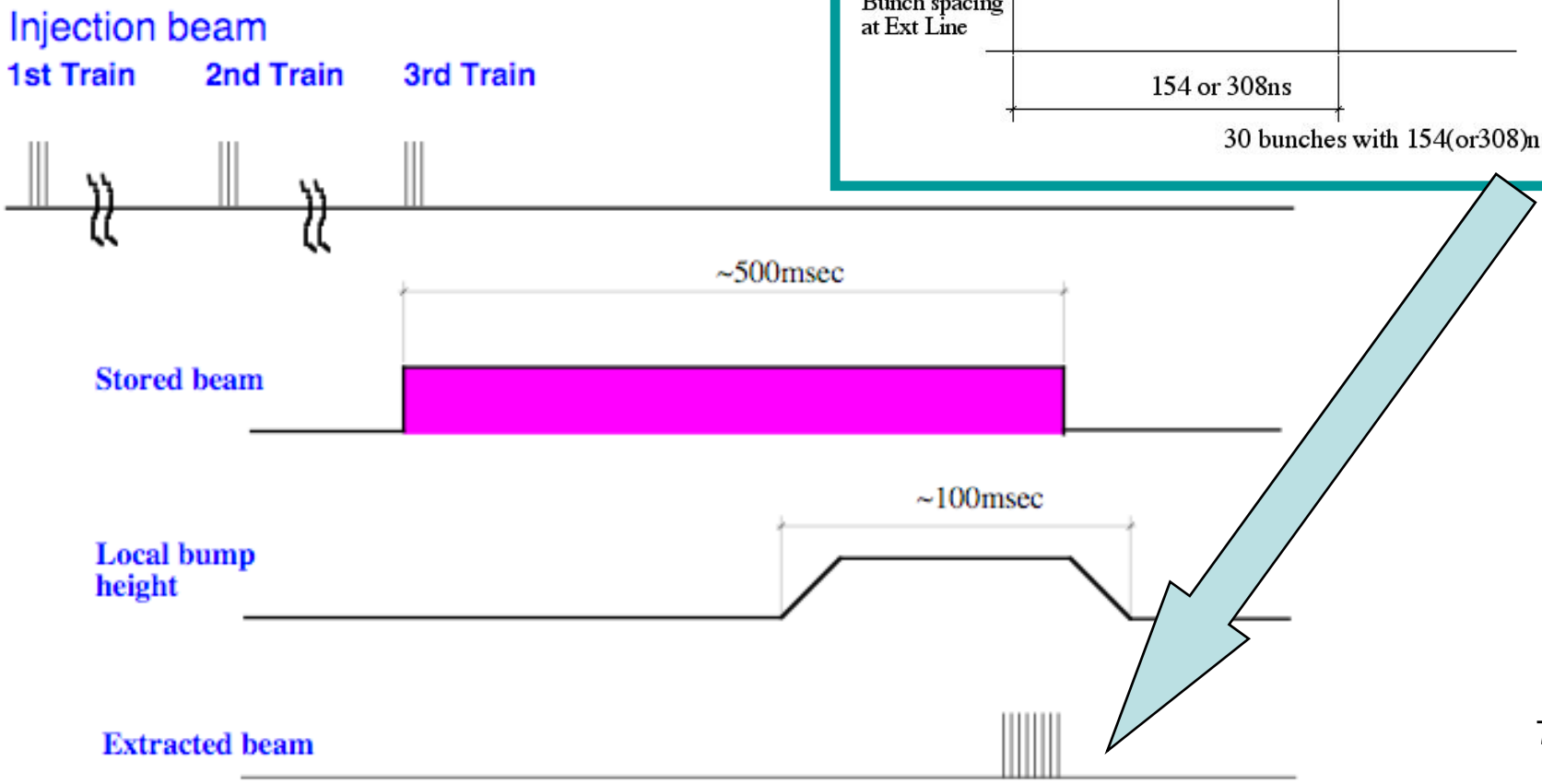
Beam extraction orbit by using Strip-line Kicker



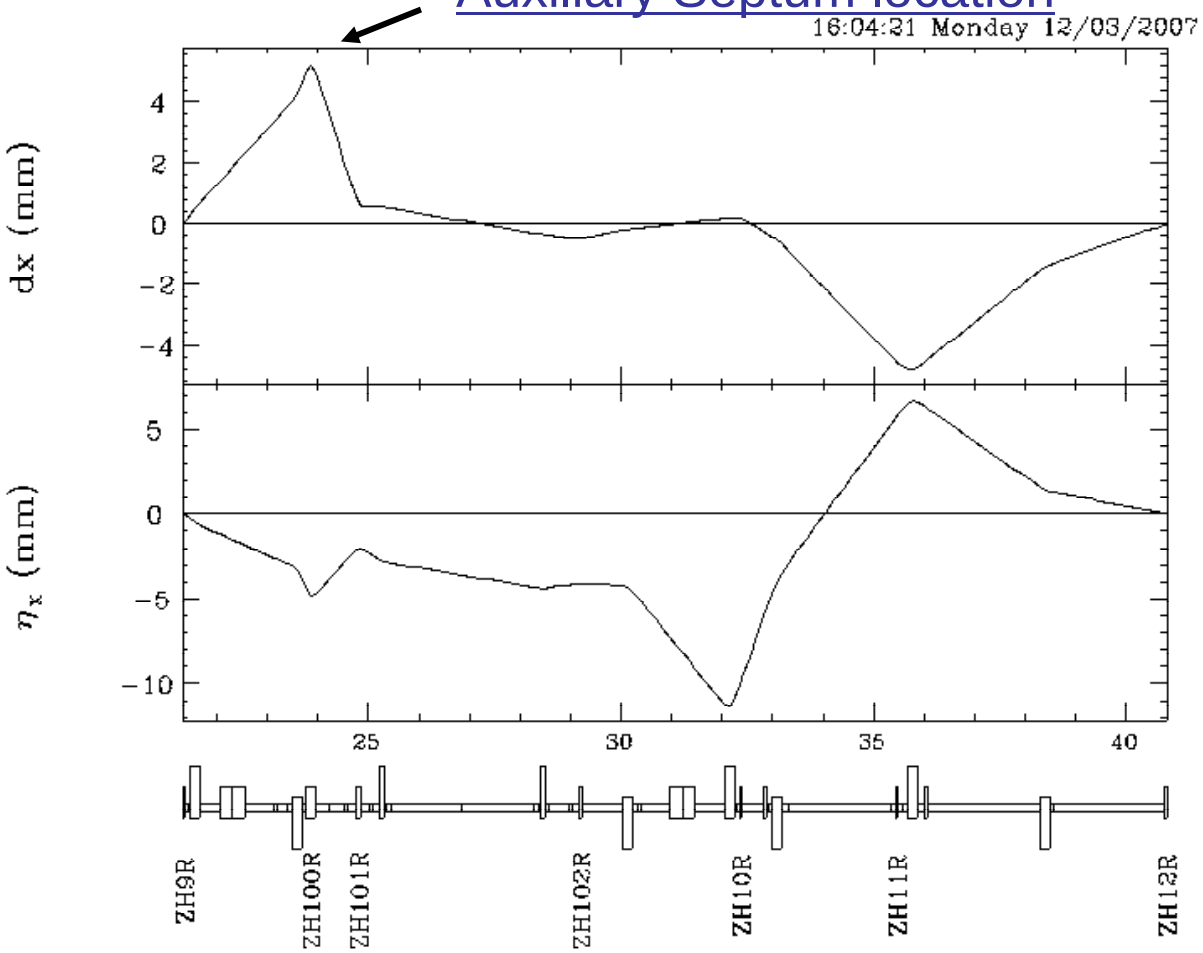
Timing chart of 30 bunches beam extraction

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



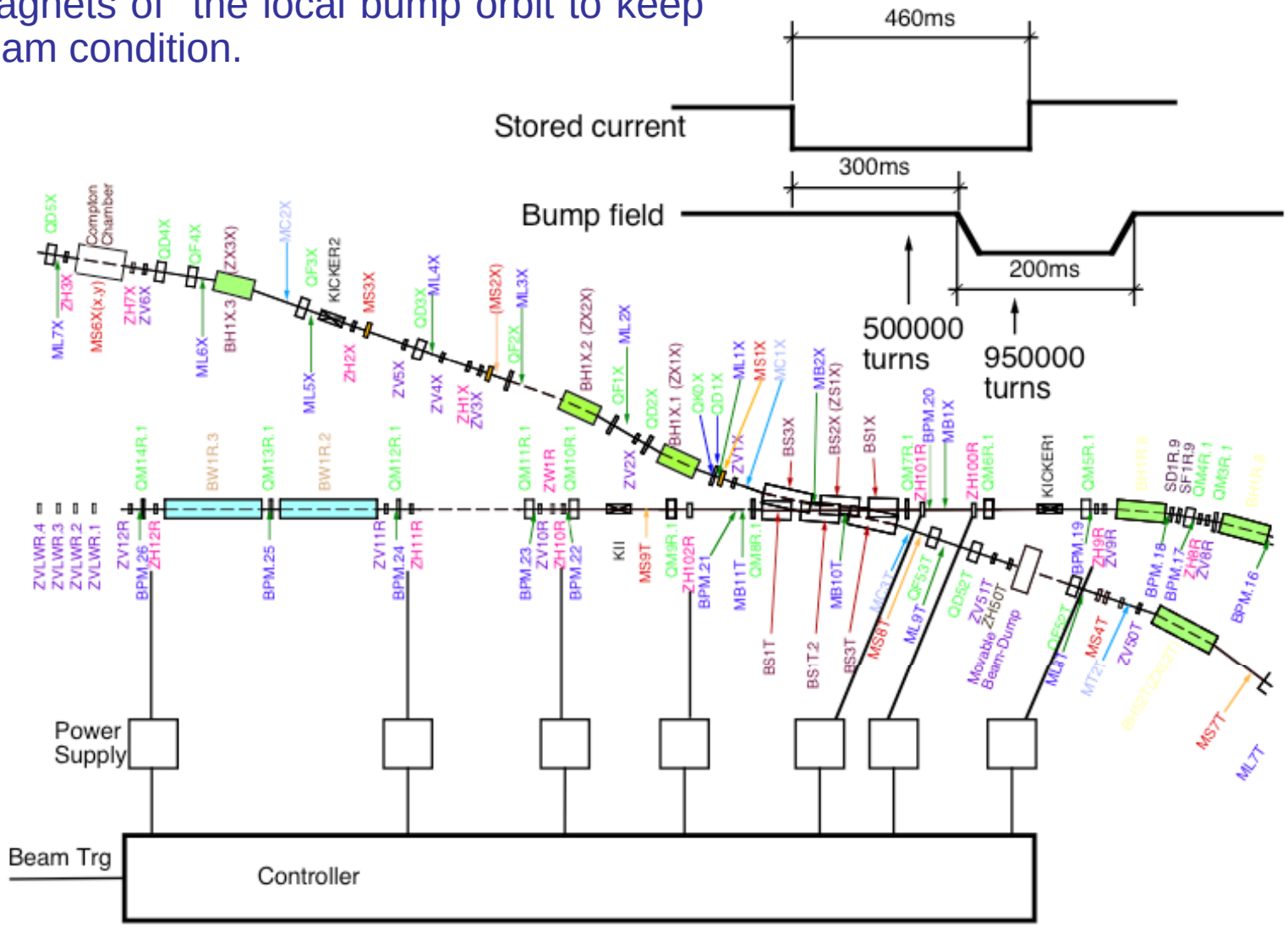
dx=5mm@ZH100R
ZH9R -.002320433716
ZH100R .010028367995
ZH101R -.005102712636
ZH102R -5.52689273E-4
ZH10R .001010243282
ZH11R -7.88468363E-4
ZH12R 5.883103424E-4

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

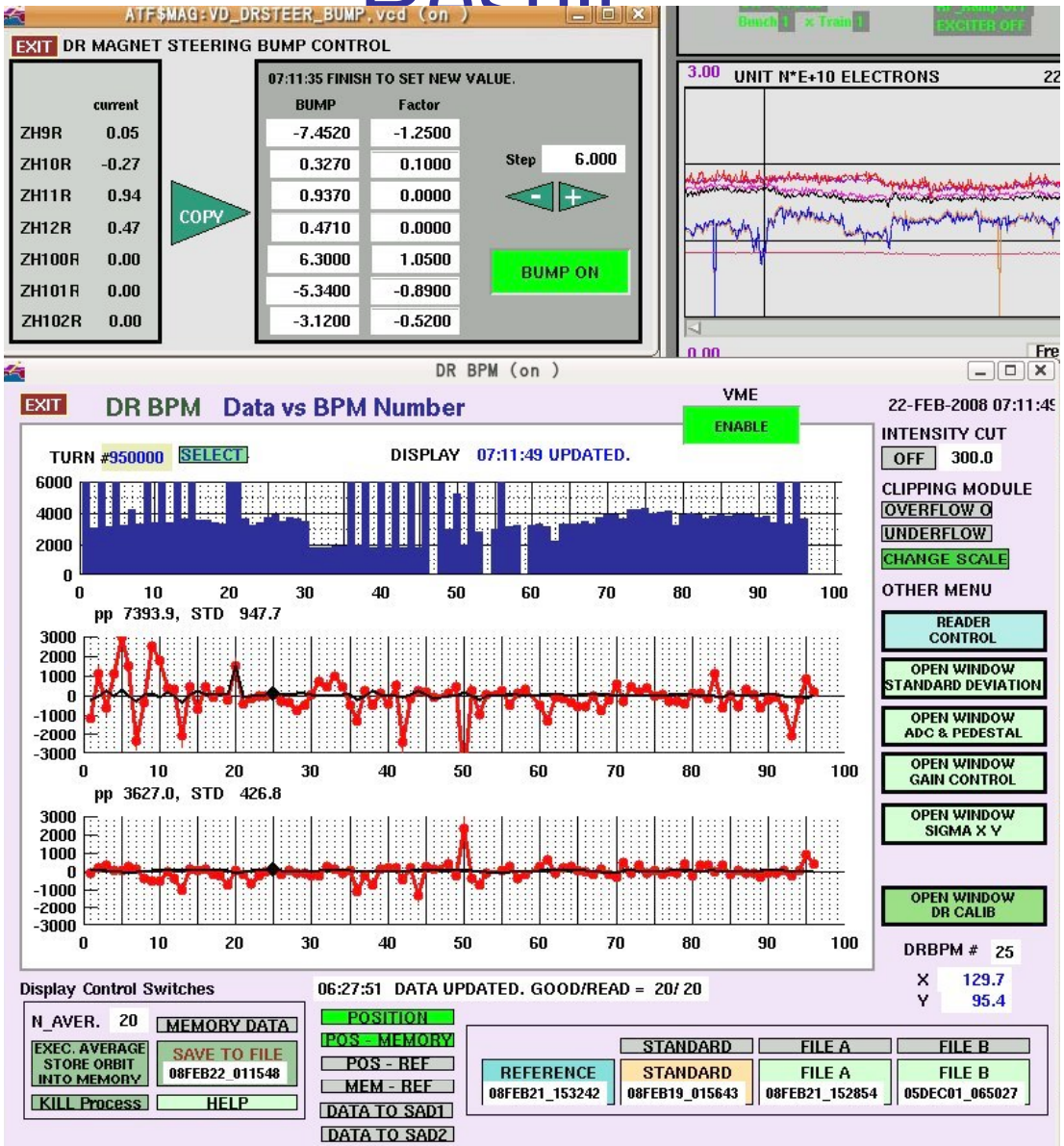
S.Kuroda

Power Supply Control for Pulse Bump orbit

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



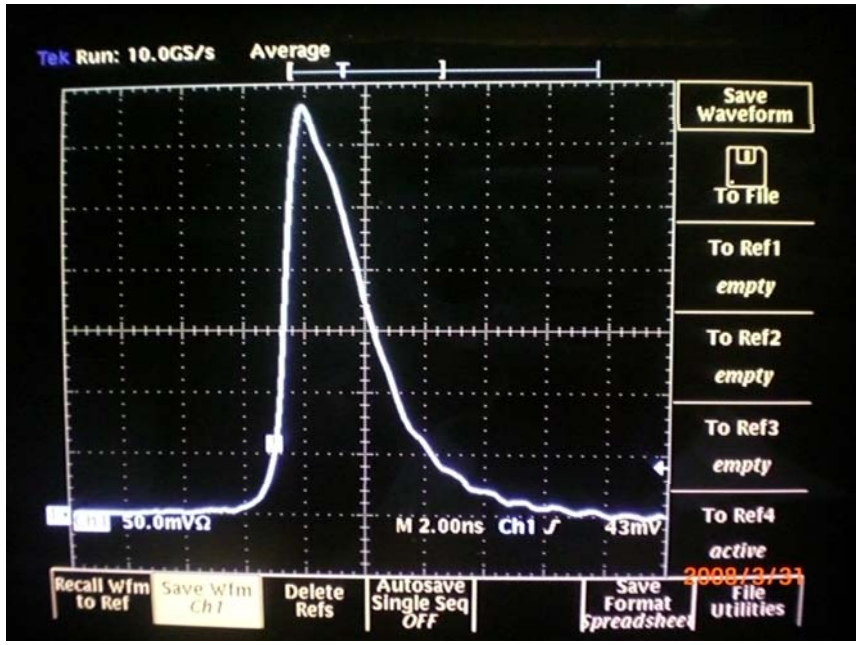
The height of the bump is confirmed by the displacement at BM20 and the magnet currents.

There is no BPM at the location of the peak of the bump. BPM20 is located at 1m downstream of the peak of the bump. The calculation depicted about 2mm of 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 show good agreement with the calculation and almost no leakage orbit at the other location. The dispersion correction is not enough at this condition.

There was no beam blow up for the vertical emittance and no beam loss at 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

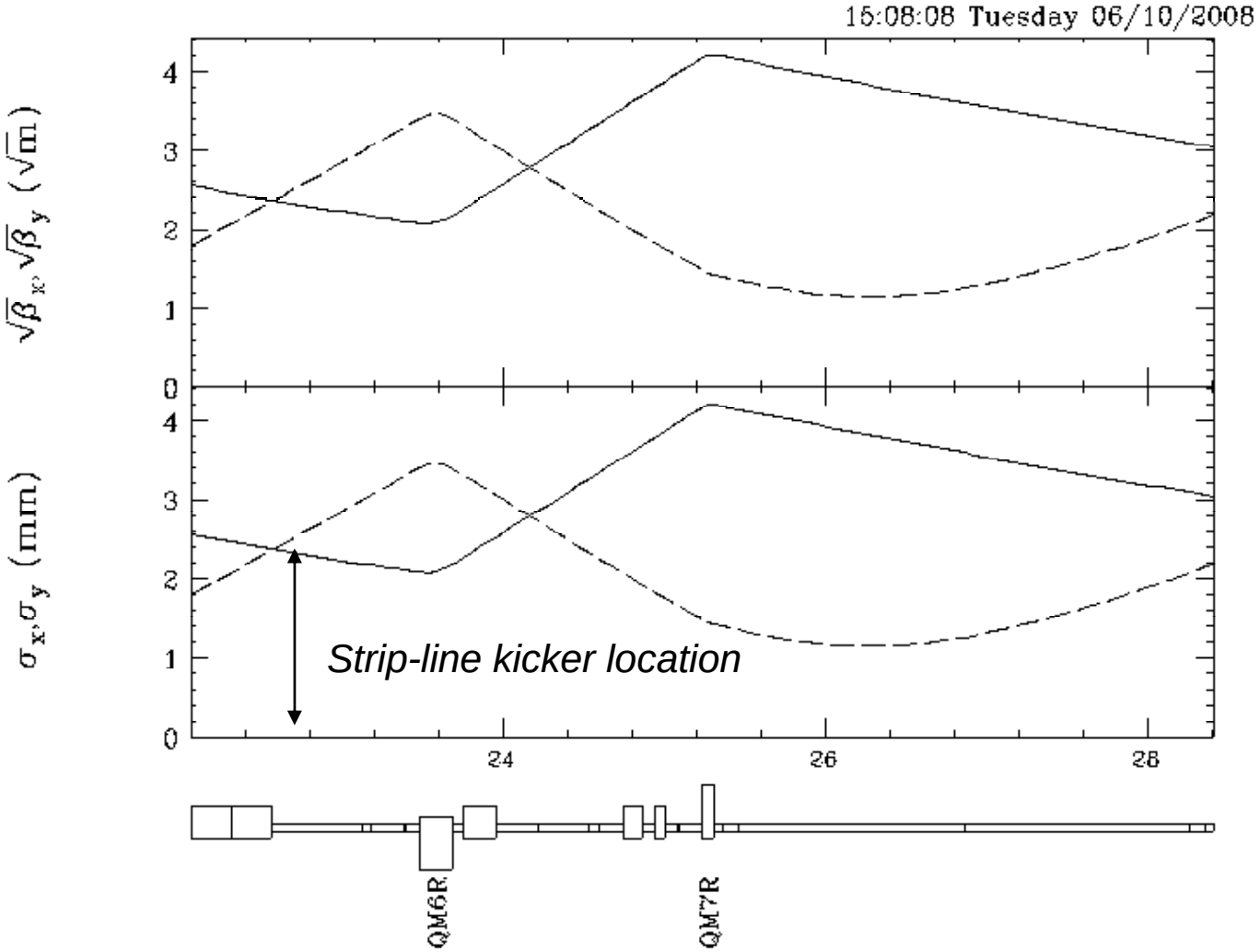
Output pulse amplitude stability - 0,5-0,7%

Maximum PRF in burst - 6,5 MHz

Number of pulses in burst - up to 110

PRF of bursts - up to 5 Hz

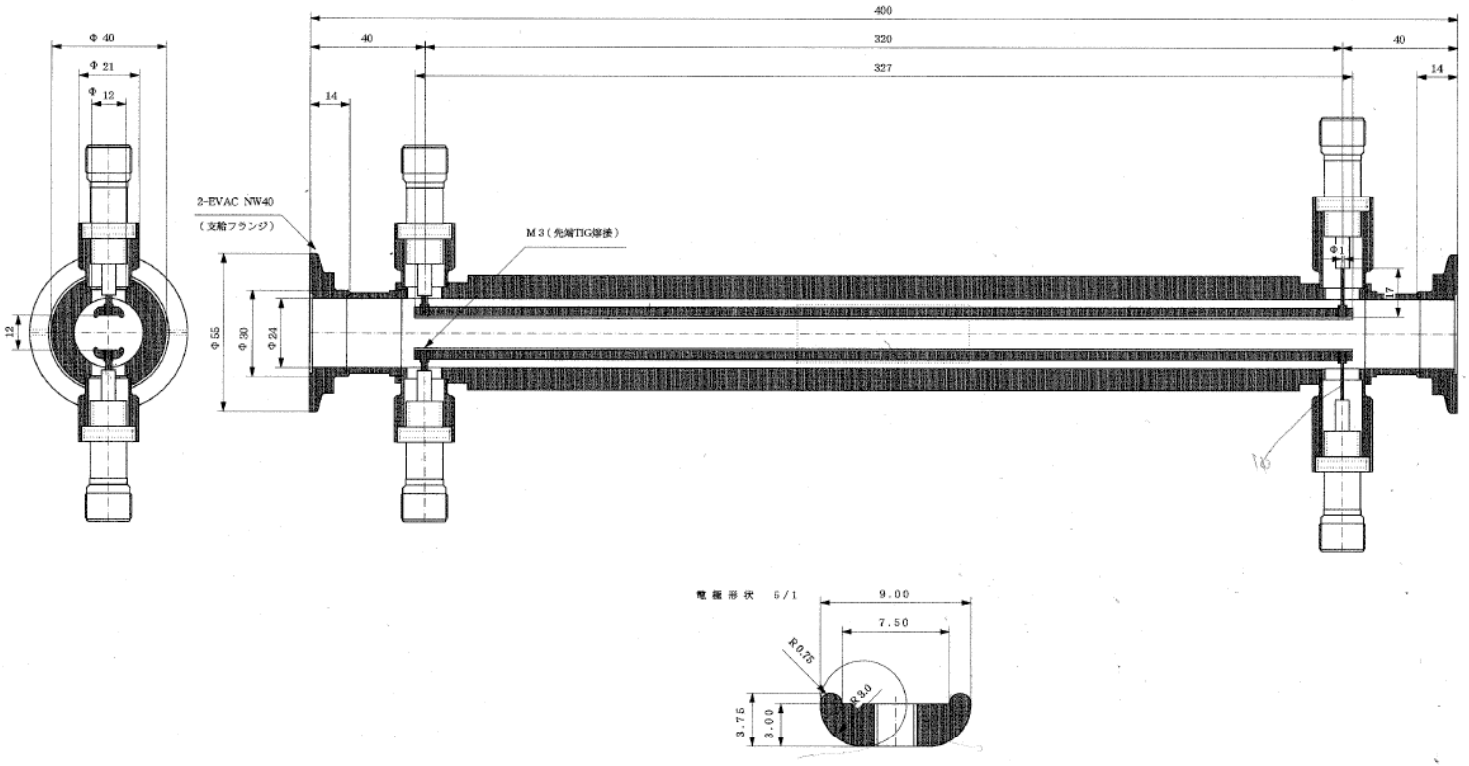
Aperture



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.

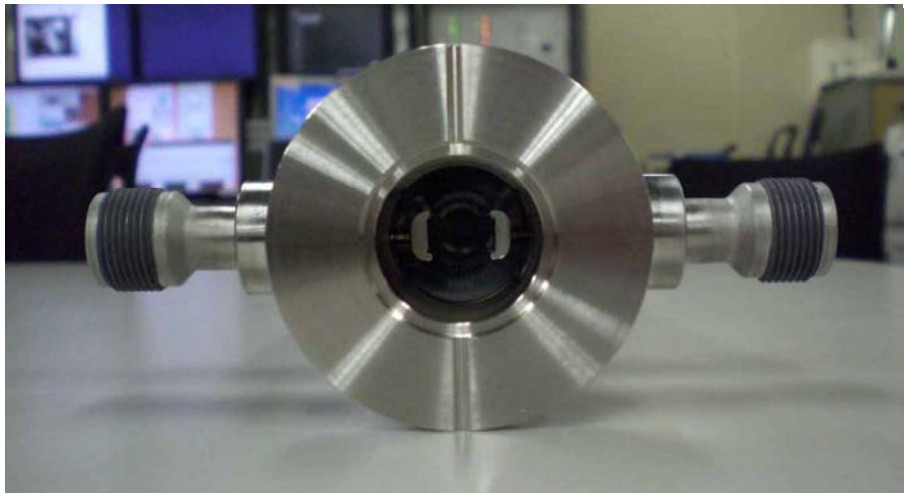
Proto type strip-line kicker(30cm long)



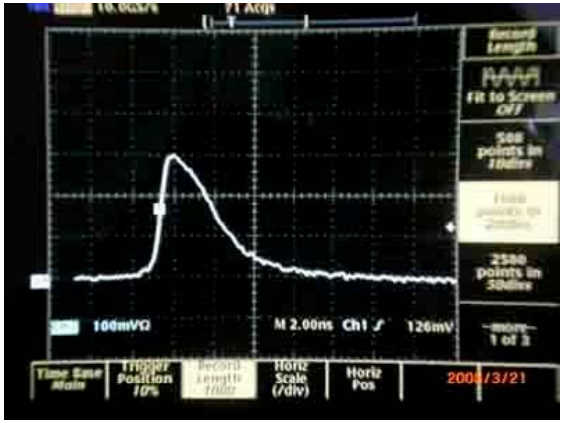
KEK fabricated a proto type 30cm long strip-line kicker, which has 12mm electrode gap. The input/output connectors are HN-type commercial available feed-through.

This version is fabricated for the kick field measurement. The length is decided by the space of the south straight section of the ATF-DR. It need to check the beam kick performance without discharge when applied +/-10kV pulse.

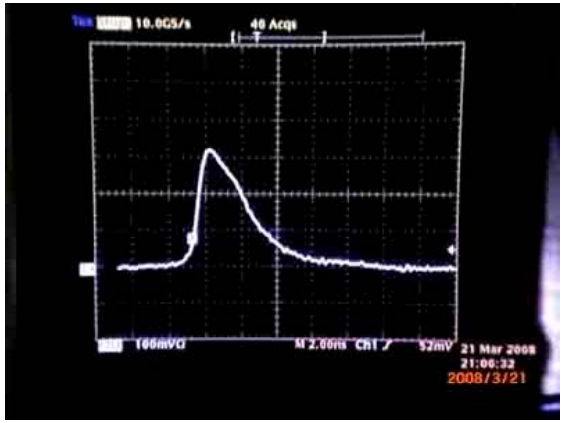
Photo of the fabricated strip-line kicker



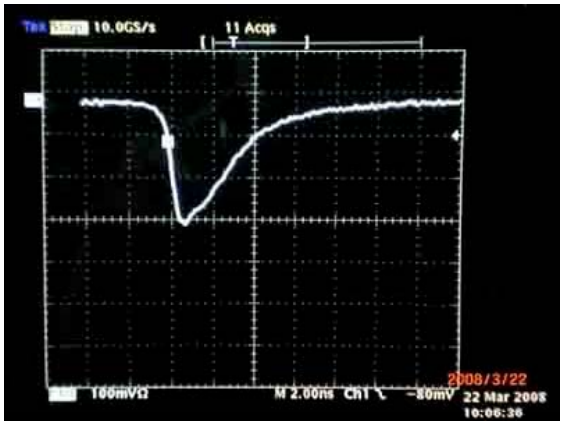
10kV pulse apply to the strip-line



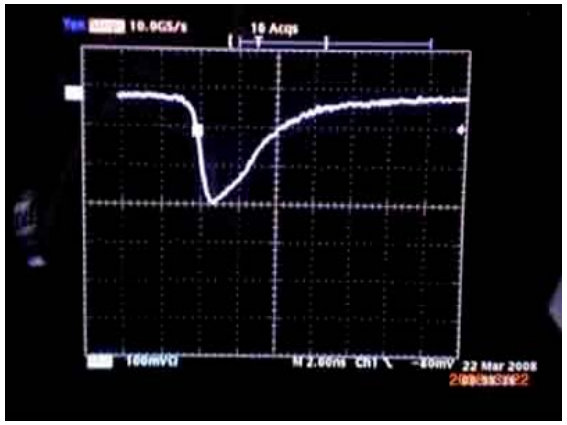
Pulser output(pos) 9.7kV peak



Strip-line output(pos)



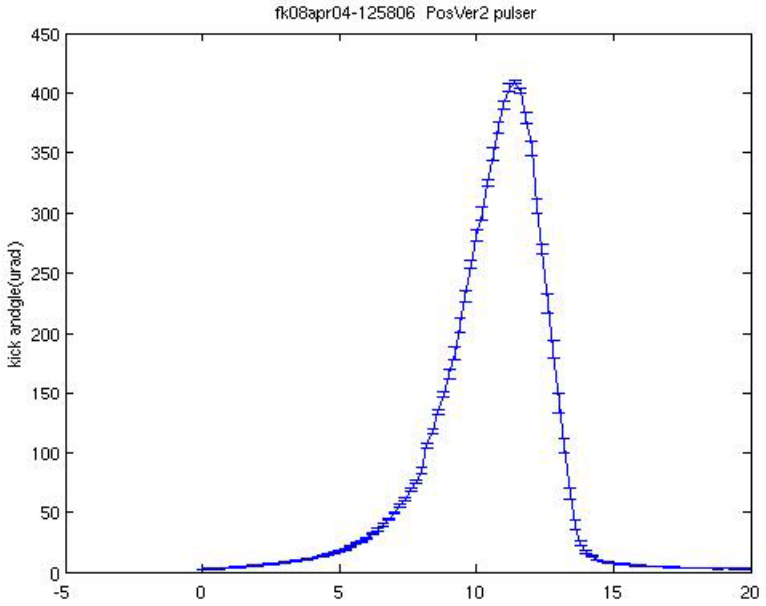
Pulser output(neg) 8.5kV peak

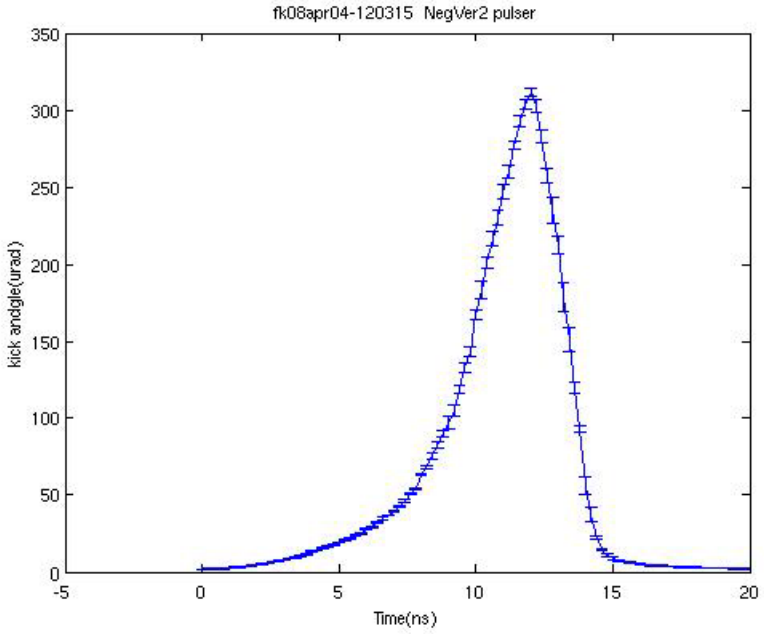


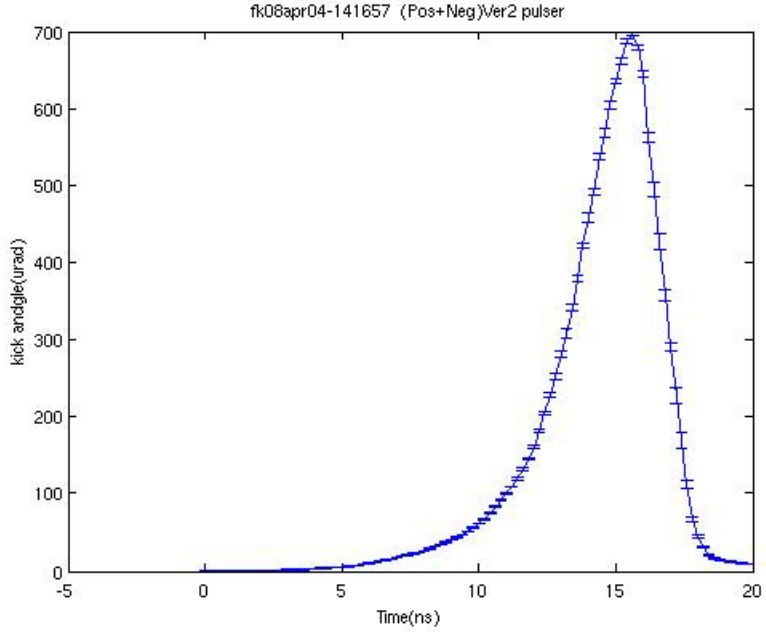
Strip-line output(neg)

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

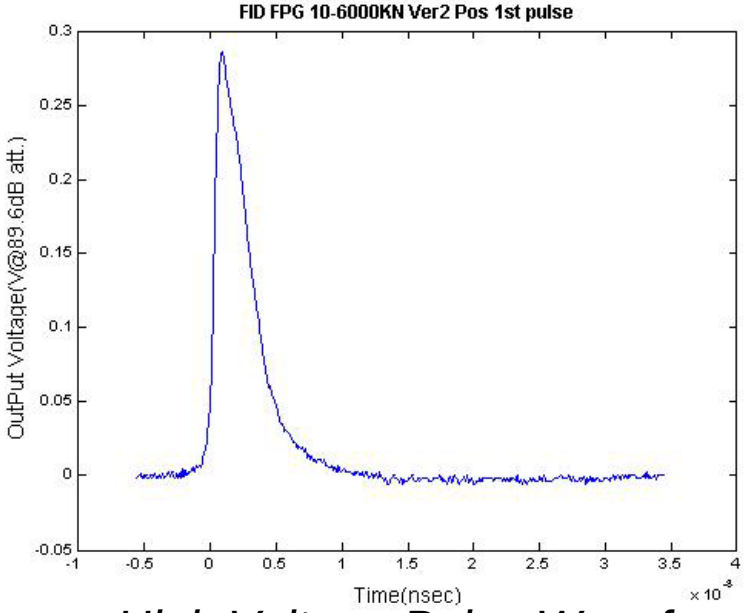




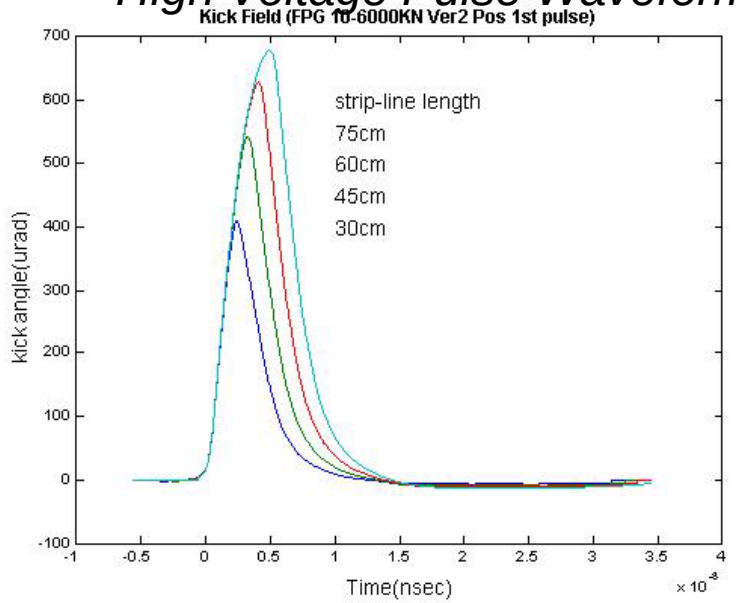


Beam kick test in the DR was carried out. The pictures show the timing scan of the kick pulses for the beam timing in the cases of the Positive, Negative and Pos+Neg pulses. The peak kick angles are 0.4, 0.3 and 0.7mrad, respectively, which agreed with the estimation from the kick voltage and the strip-line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

Estimation of kick angle



High Voltage Pulse Waveform

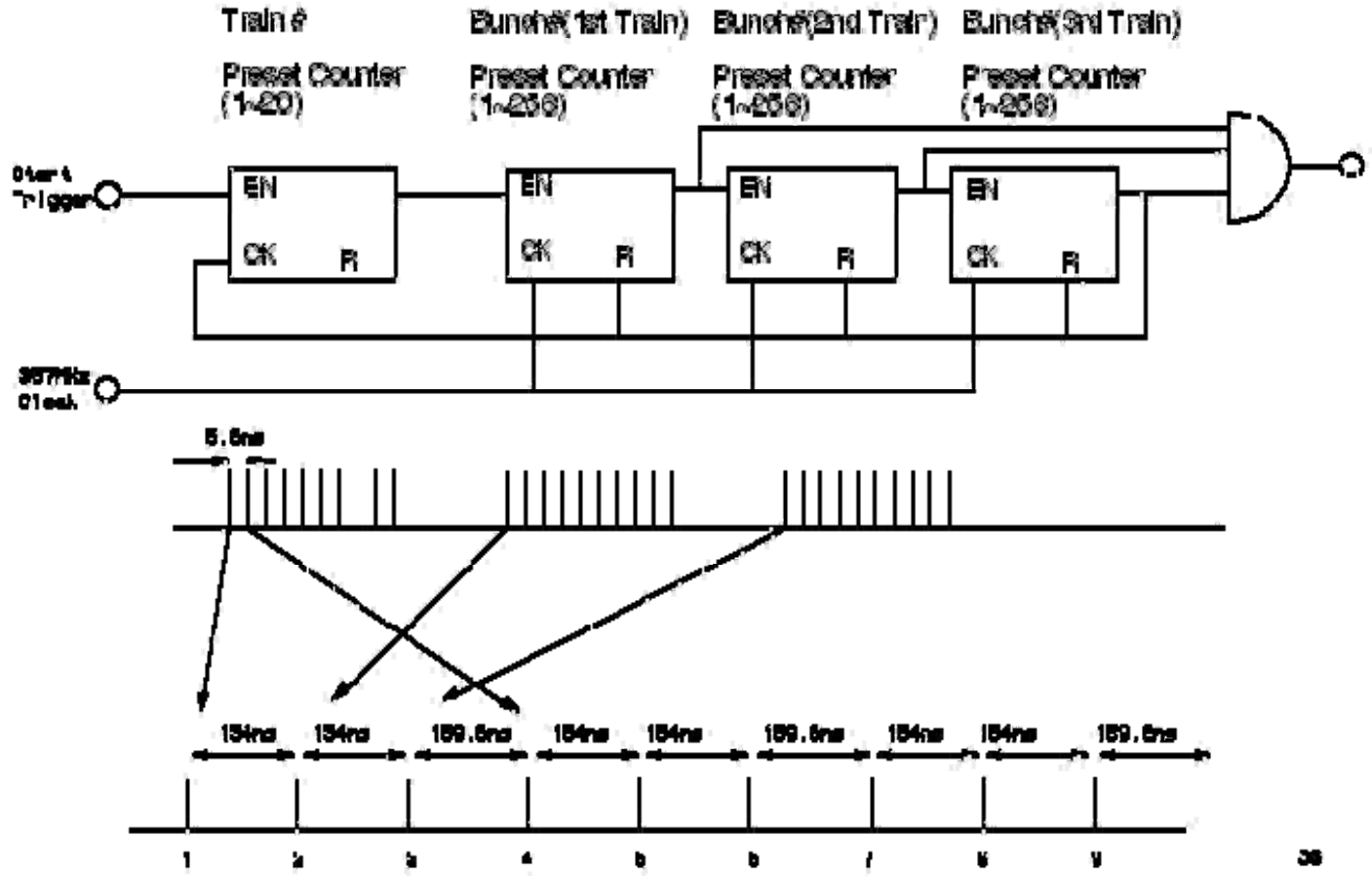


Calculation of the kick field

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 from 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 pusers(positive/negative) for each strip-line and two unit of 60cm long strip-lines are used, the total kick angle is 2.4mrad.

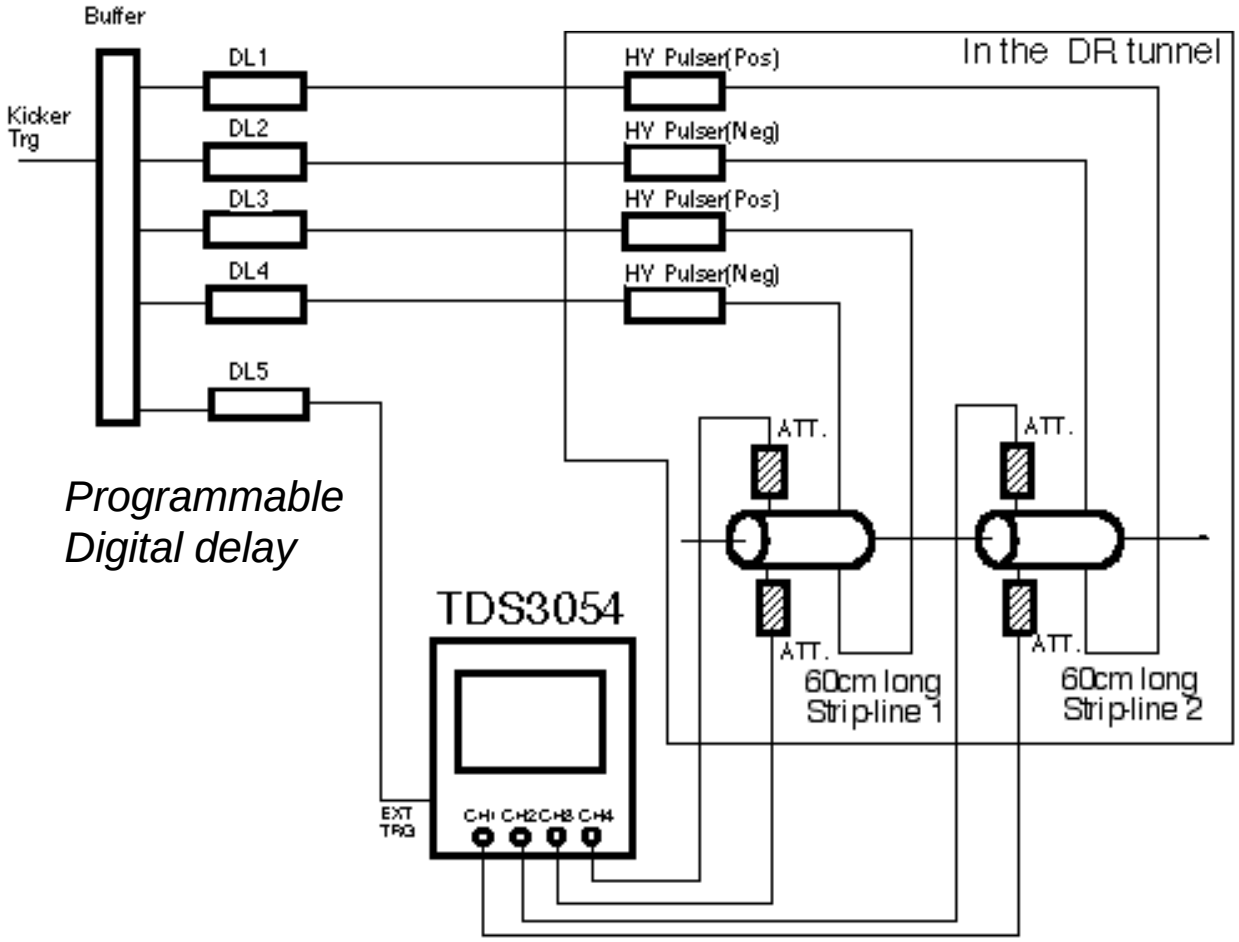
Pulse train generator



Special timing pulses are required for the strip-line kicker. The pulse timing needs to shift one bunch spacing every three pulses interval. This circuit is under fabrication.

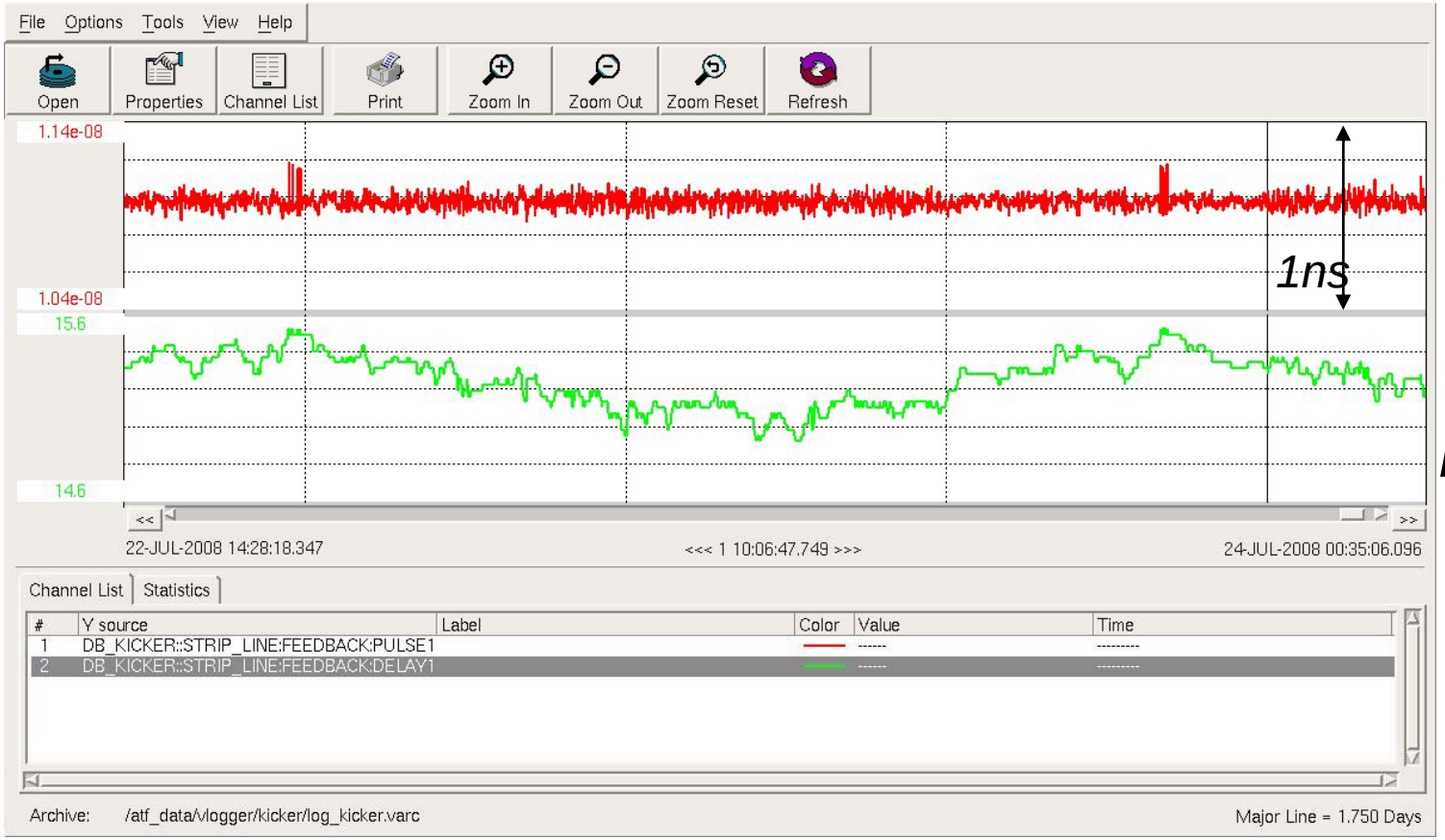
Trigger timing FB for Strip-line kicker

20080115 T.Naito



Precise triggers for each pulser and the timing control is required. The pulse measurement by scope and the timing control by digital delays consist 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

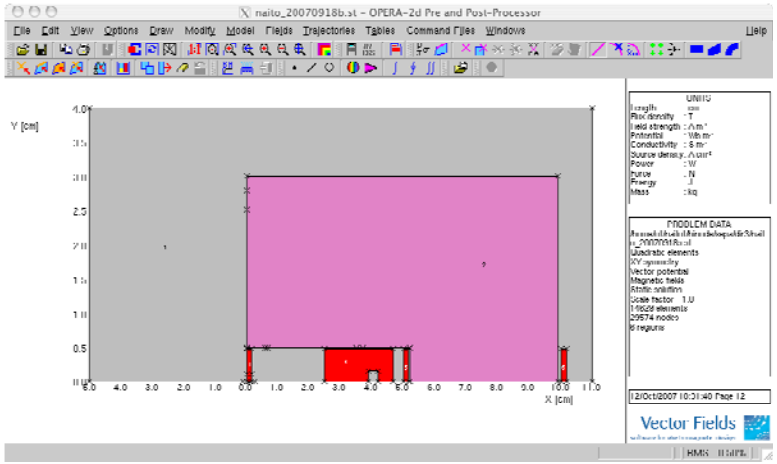


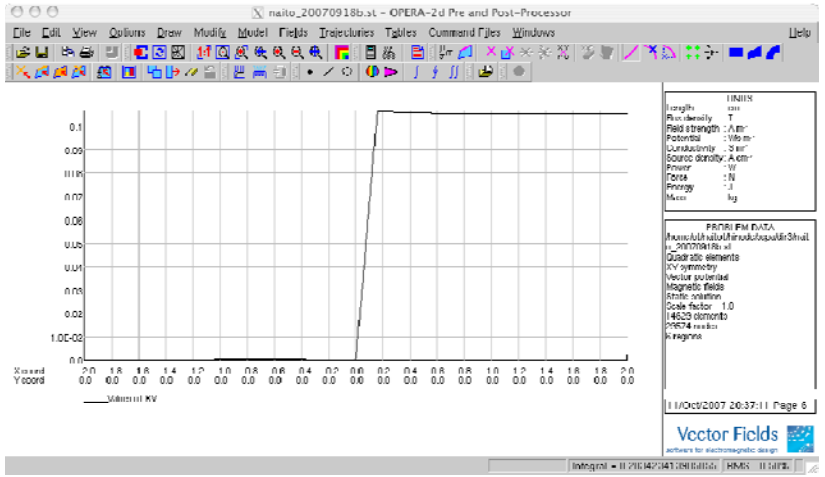
Measurement

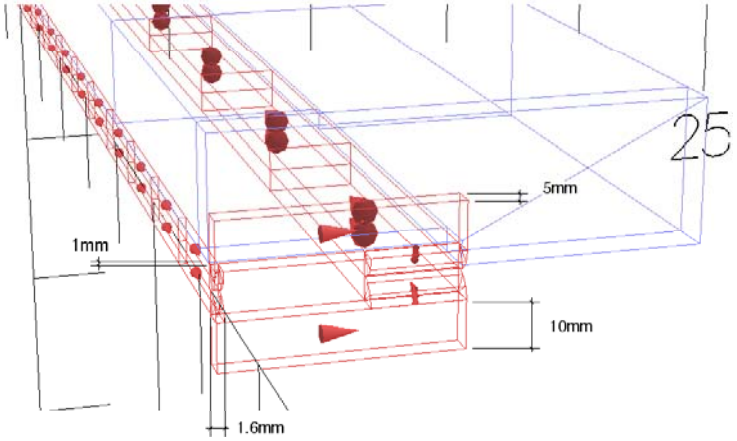
Delay Setting

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 less than 200ps except for a bit error of 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.

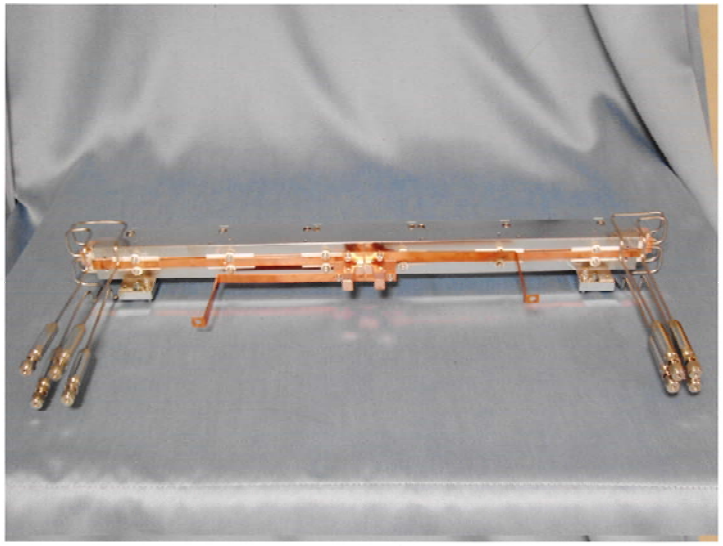
The designed auxiliary septum magnet has 1.6mm of a thin separator and 0.1T of bending field.

Auxiliary septum

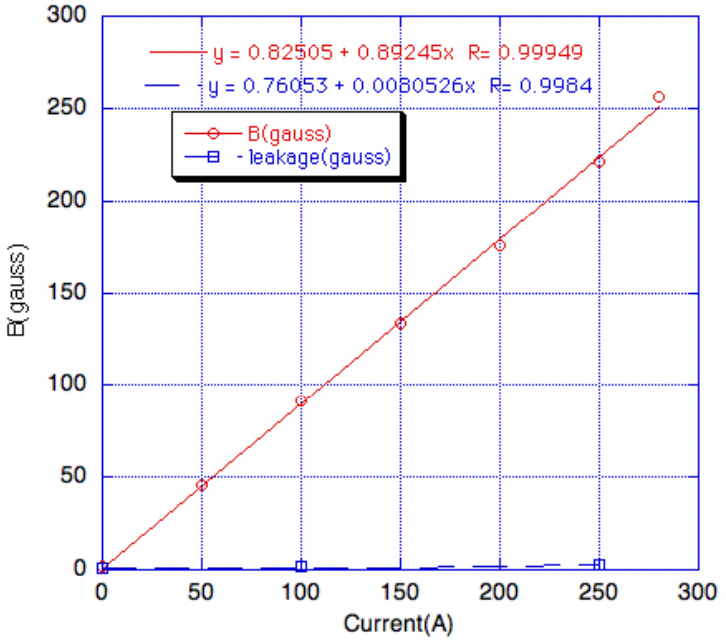
The current test up to 300A was done without any temperature problem. The leakage flax is less than 1%, which can be compensated by the auxiliary coil.

Aux. coil(1turn)

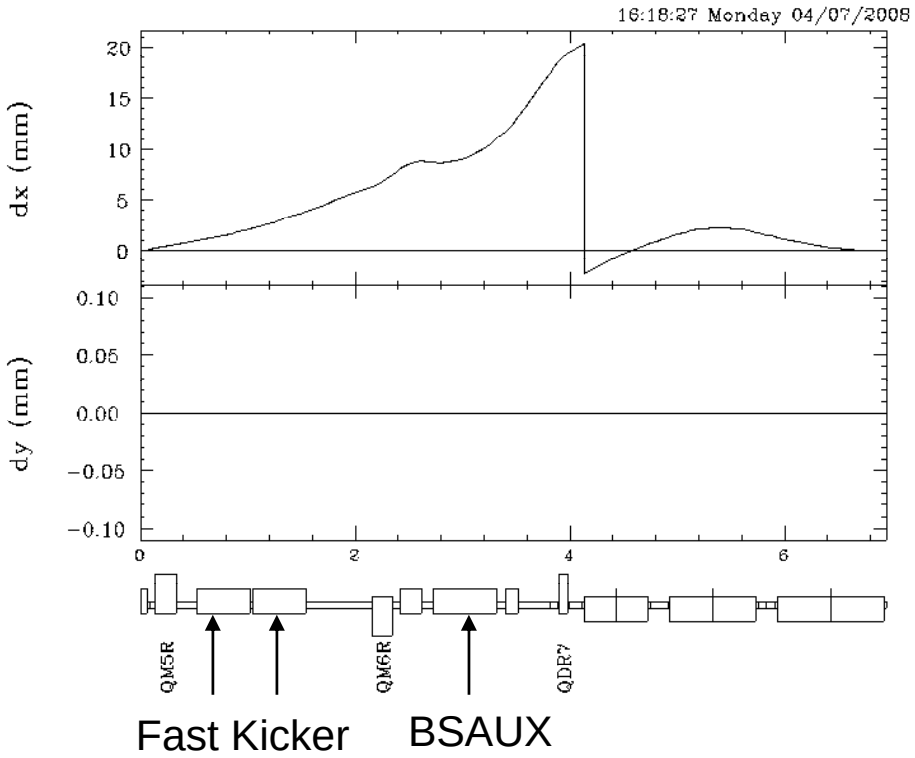
Main coil(1turn)



Feild Measurement of the Auxiliary Septum Magnet



EXT Orbit with Fast Kicker *S.Kuroda*



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)

2008/12/17

Beam Extraction Test

- *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,
- *Stability measurement 2days*

Beam Extraction Test Schedule

- Installation of strip-lines and Auxiliary Septum 22-26Dec2008
- Check of the hardware and software 5-9Jan2009
- Beam extraction test 13-23Jan2009
- Get back to present pulse magnet 26-30Jan2009

Vacuum work 1 week each(before and after)
Beam extraction test 2 weeks