Kicker Test at ATF

Junji Urakawa (KEK)

for

ATF International Collaboration

ATF

Accelerator Test Facility

ILC like beam for ATF2

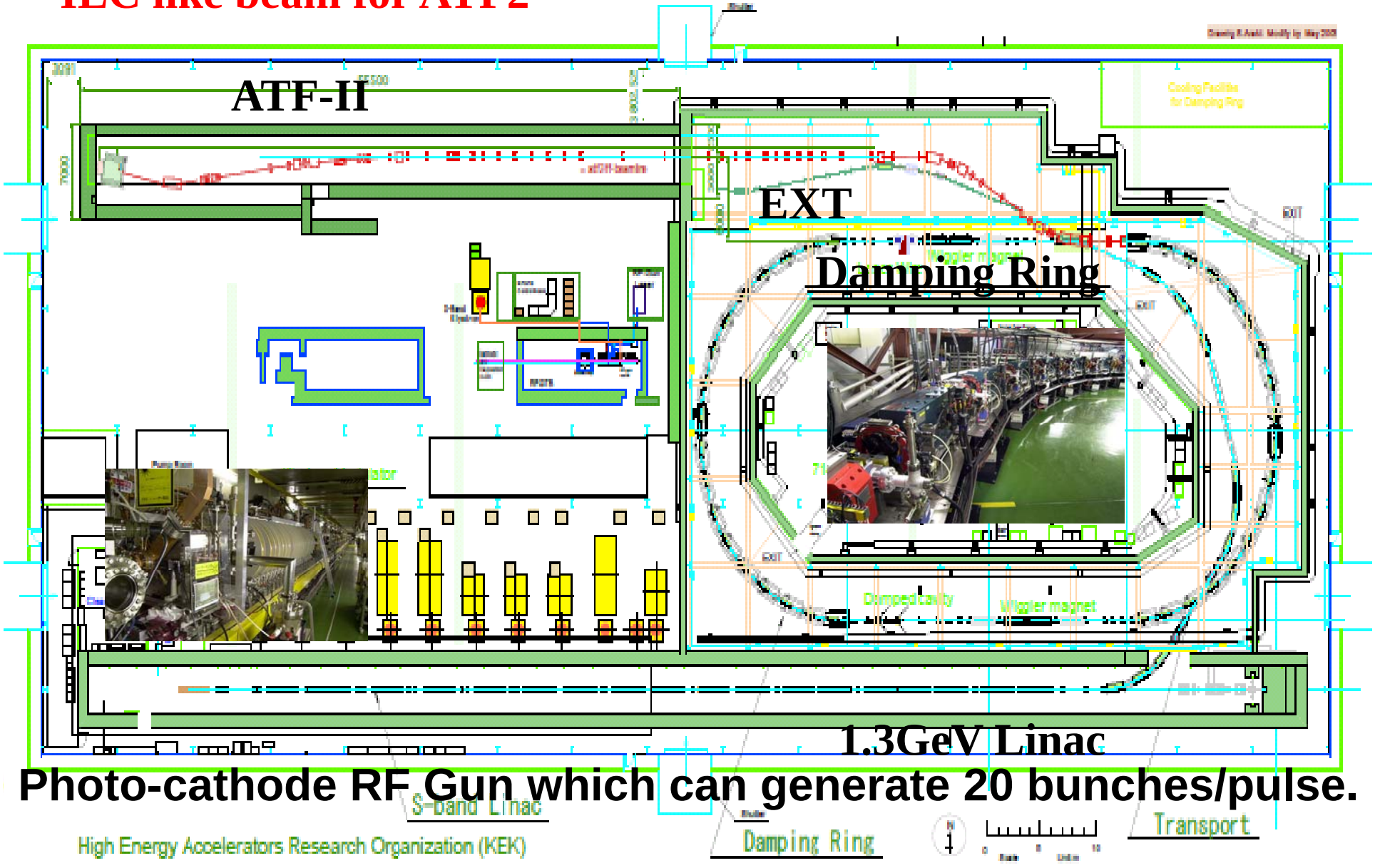


Photo-cathode RF Gun which can generate 20 bunches/pulse.

ATF (Accelerator Test Facility)

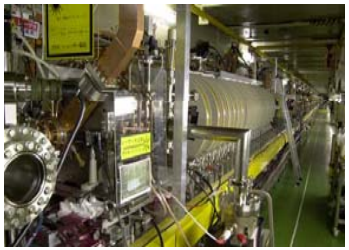
Energy: 1.28 GeV
Electron bunch:
- ***2x10^{10} e/bunch***
- ***1 ~ 20 bunches/train***
- ***3 trains/ring***
- ***1.56 Hz***

$\varepsilon_{x/y}$ ~ 1.5nm/4pm

Cavity BPM
nm resolution
beam position monitor

Pulsed Laser Wire scanner
Beam size monitor

Extraction line
Beam supply for BDS Exp., instrumentation R&D



Damping Ring
Low emittance beam generation
Study on beam instability
Instrumentation Development

Fast kicker
Strip-line fast kicker development

CSR

XSR

S-band Linac

Photo-cathode RF gun

Beam Kick test of Fast kicker (KEK, LLNL, SLAC, LBNL,LNF)

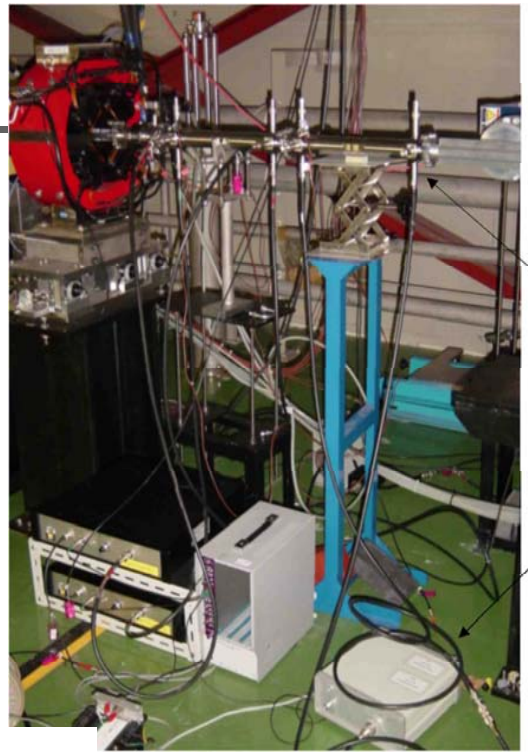
2005-2006

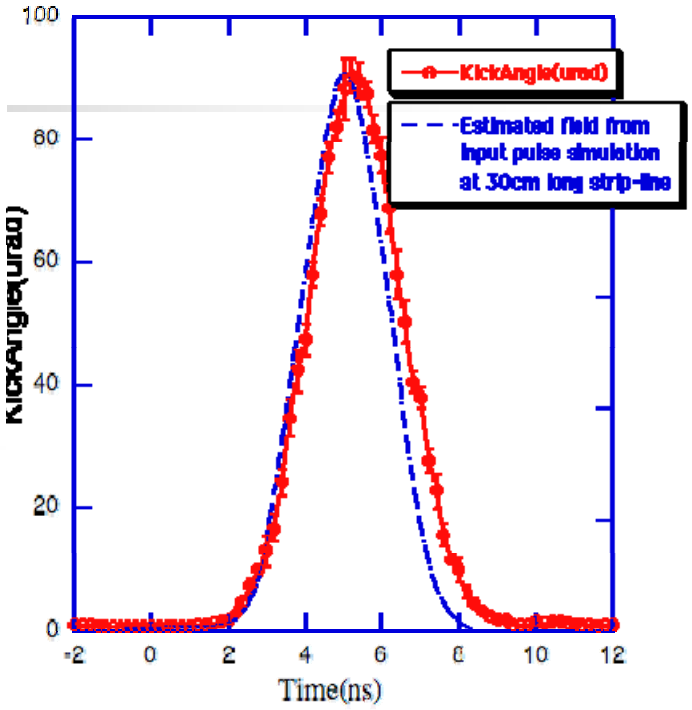
Rise time＜3 ns

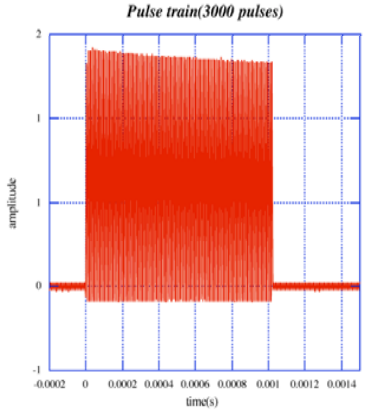
Evaluation on kick angle from coherent beam oscillation in ATF damping ring

2007～2008

Design and demonstration for real beam extraction.







Pulse Train (3000 pulses)output from FID Pulser

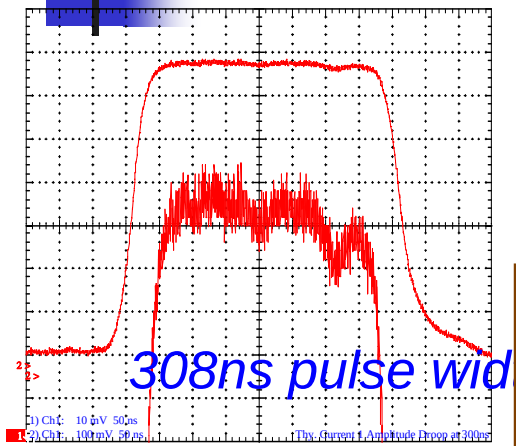
Burst pulses(3MHz, 3000pulses)

Rise time = 3.2ns (1%~100%)

Fall time = 4.0ns (100%~1%)

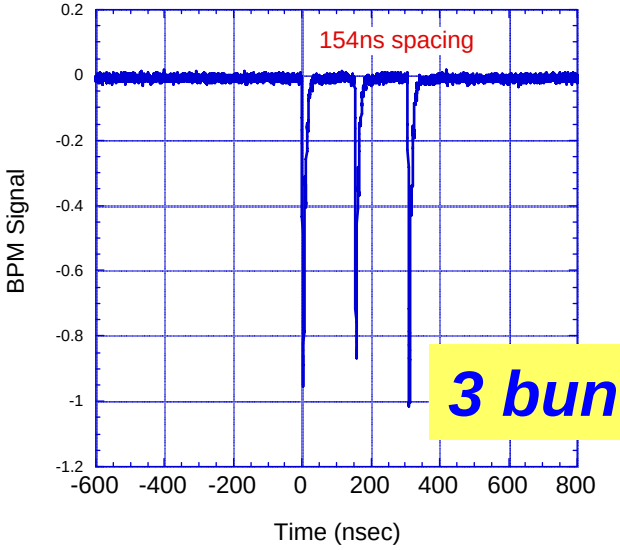
Design and beam test for strip-line fast kicker experiment

Present kicker stability (Pulse magnet kicker system)

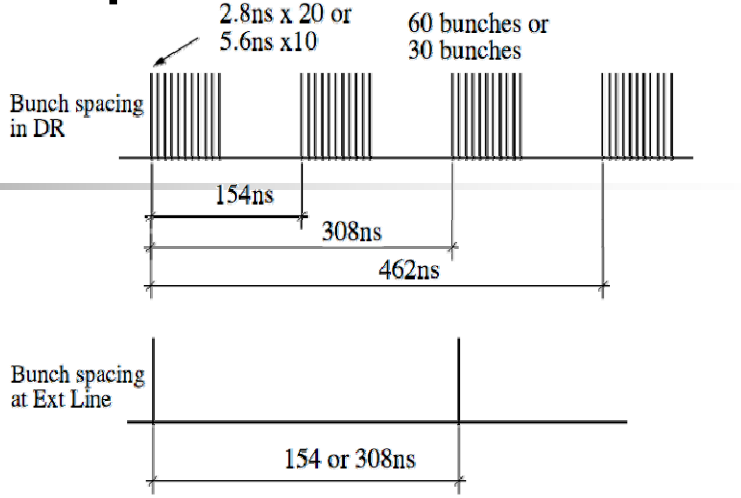


308ns pulse width

(Single bunch) x 3 Train Extraction



3 bunches, 154ns spacing

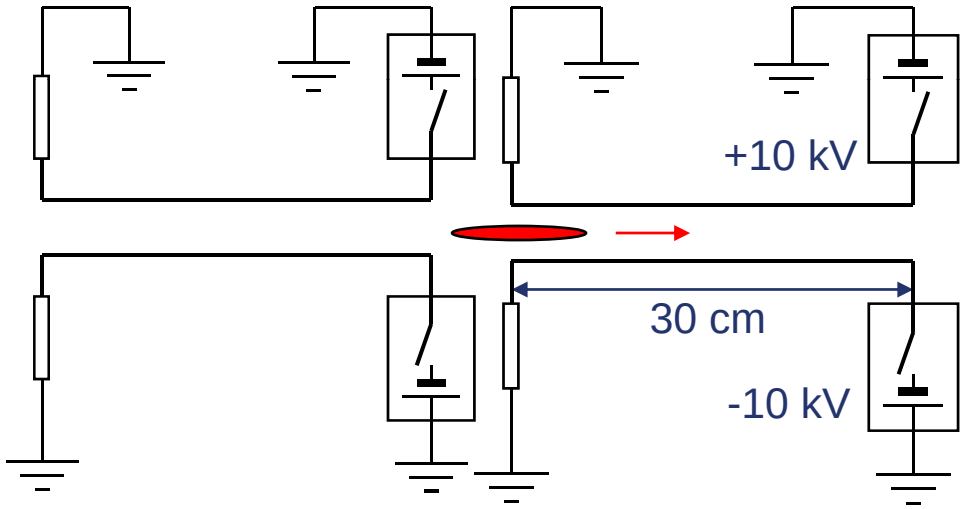


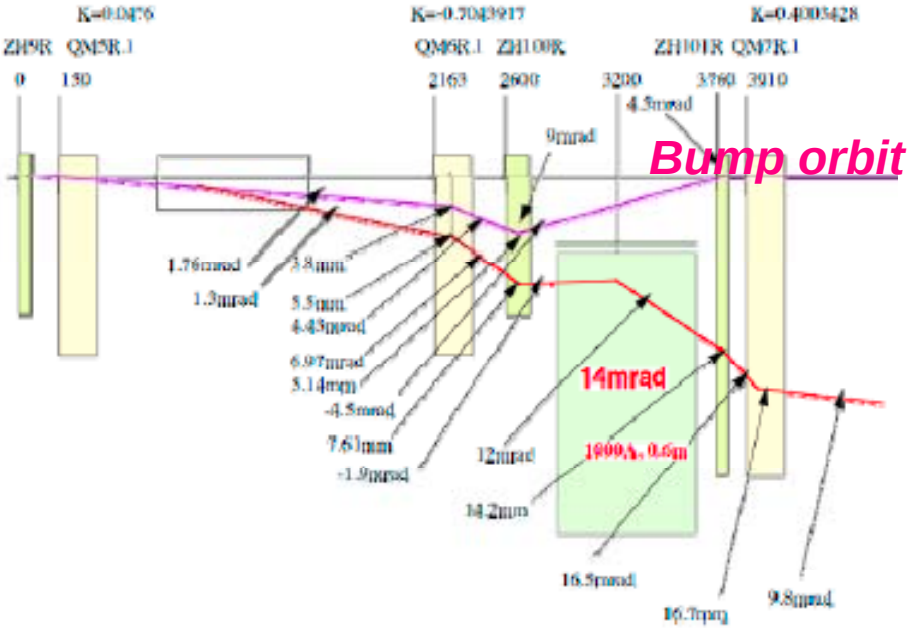
10kV 1ns:rise time, fast Pulse power supplies

Multi-bunch beam supply to ATF-Ext.
60 bunches with 154 ns spacing.
30 bunches with 308 ns spacing.

Future Kicker Tests at ATF

New septum and a "slow" orbit bump would allow fast extraction using two 30 cm strip lines, driven by ±10 kV pulsers.

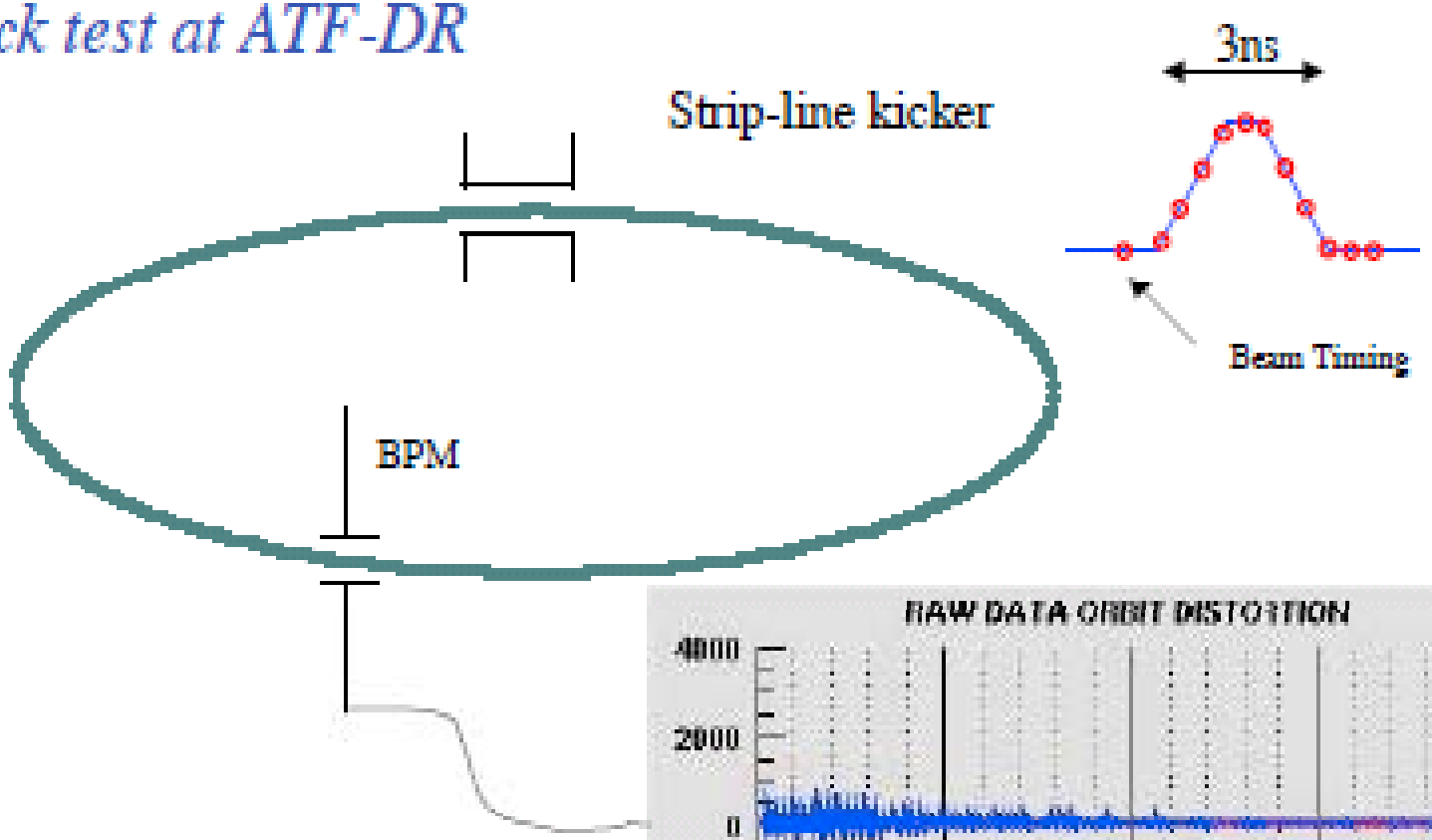


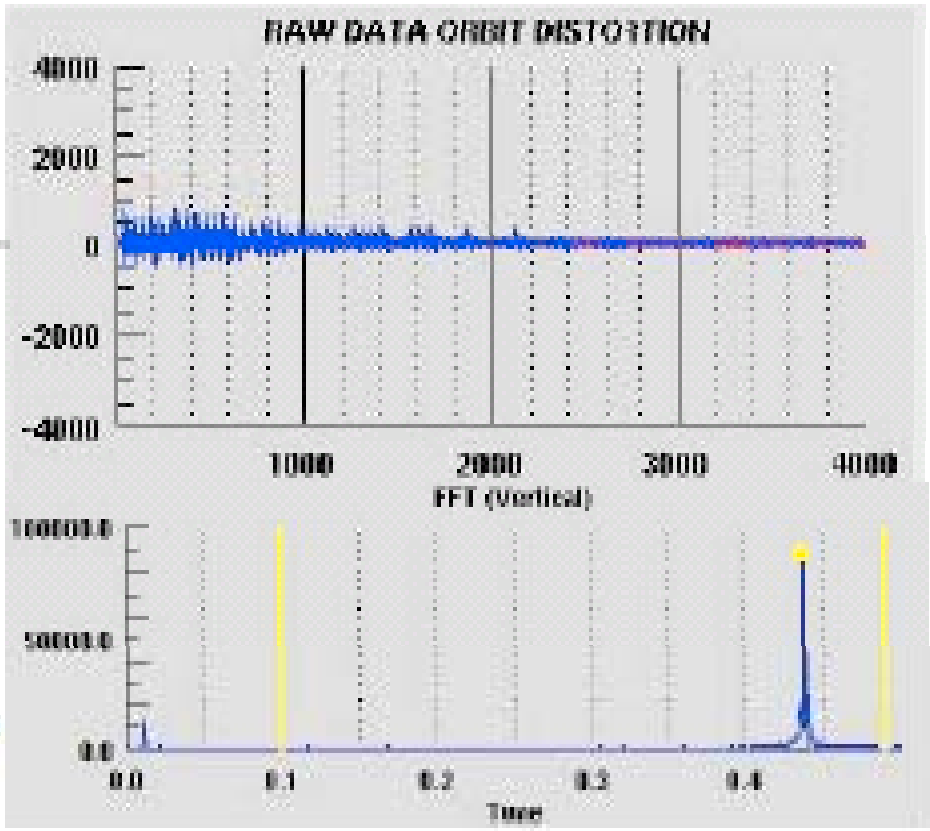


The length of each strip-line is limited by the rise and fall time specifications: the maximum length is approximately 30 cm.
Each strip-line is driven by two pulsers operating at ±10 kV, providing a voltage between the electrodes of 20 kV.

Beam extraction at the end of 2008

Beam kick test at ATF-DR



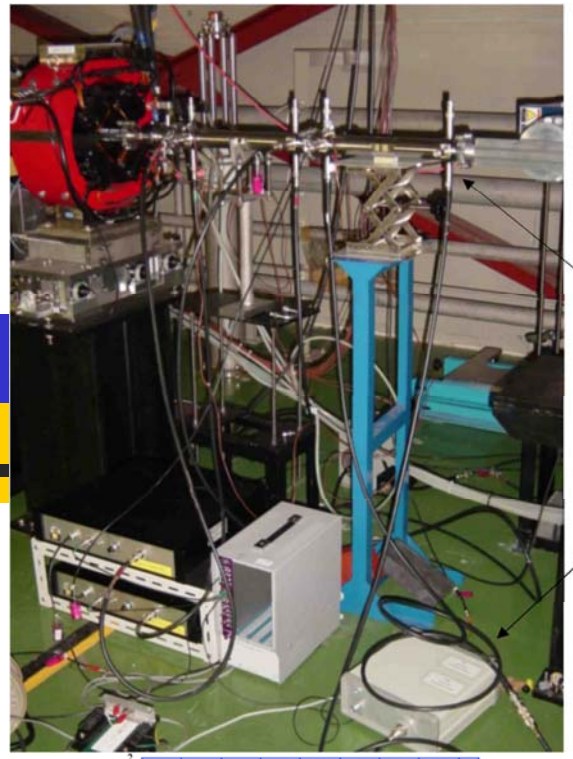


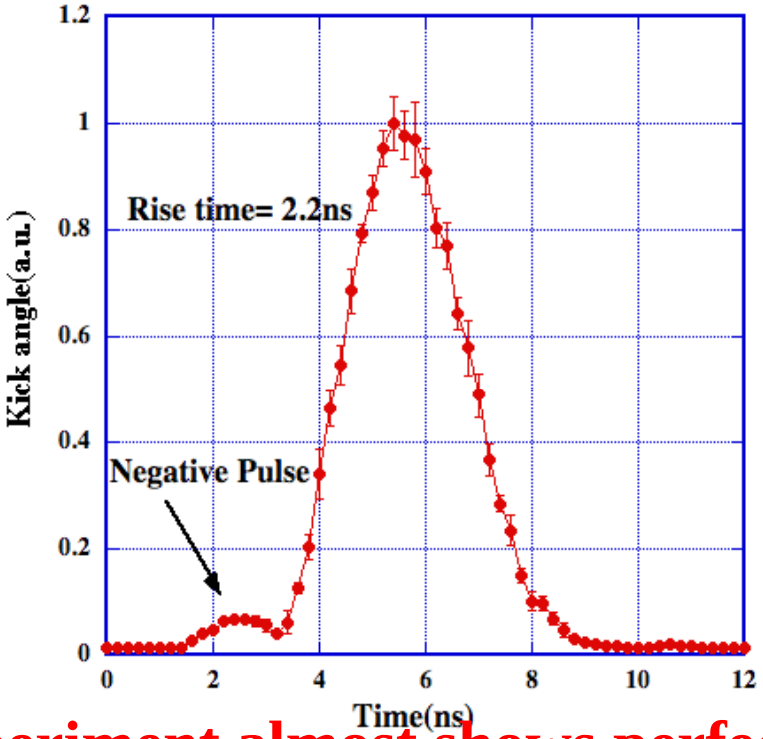
The kicker pulse is applied to the strip-line electrode at just the time of the beam goes through the electrode.

The beam kick is observed by a turn-by-turn BPM as the amplitude of the oscillation of the betatron frequency component.

The kick effect is measured by scanning the pulse timing.

Beam Kick test of ILC Fast kicker (KEK,LLNL,SLAC,LNF,LBNL,DESY, FID)

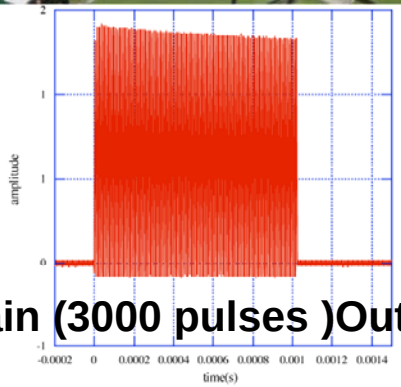




This experiment almost shows perfect kick timing control.

rise time improvement
by using waveform compensator.

3 ns -> 2.2 ns

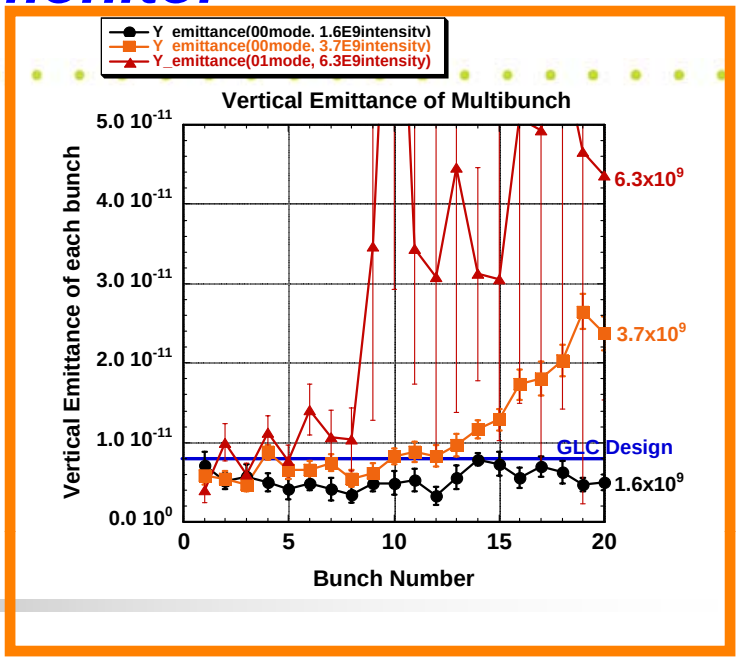


Pulse Train (3000 pulses)Output from FID Pulser

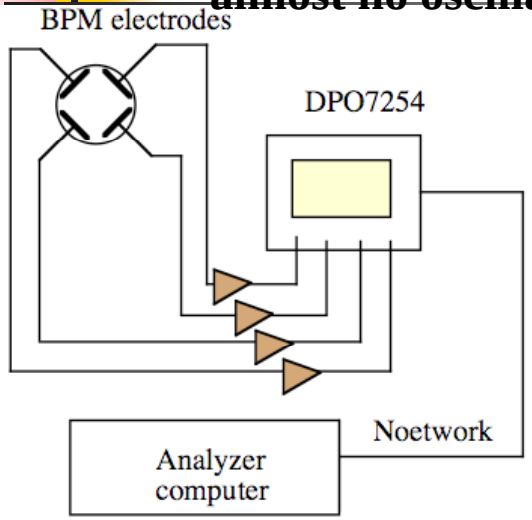
Multi-bunch Turn-by-turn monitor

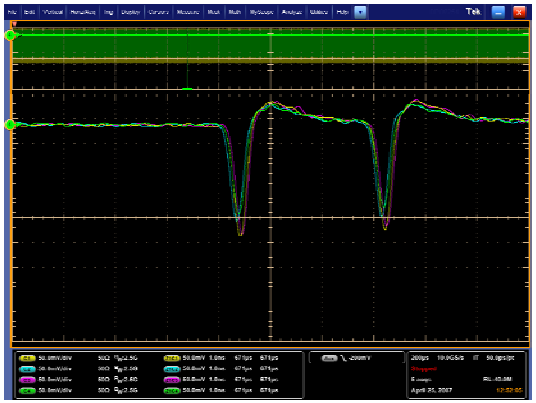
T. Naito (KEK)

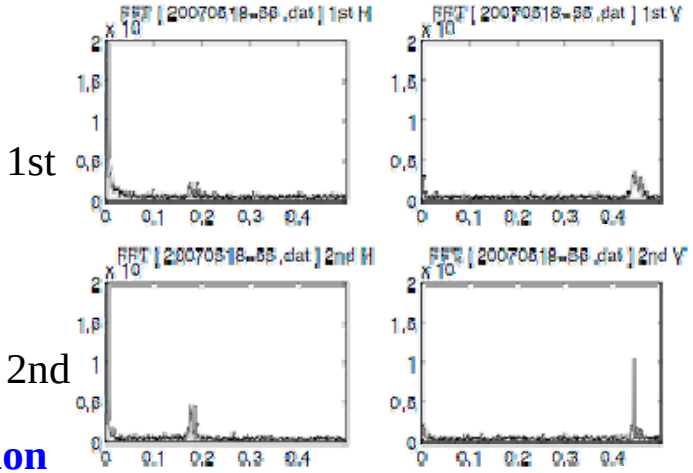
The beam blowup at tail bunches was measured by the laser wire in ATF, which is assumed coming from FII effect. In order to observe the individual beam oscillation in the multi-bunch beam, multi-bunch turn-by-turn monitor has been developed. This monitor consists of front end circuits(amplifier and filter) and DPO7254 scope. The scope can store the waveform up to 2ms with 100ps time resolution.



When one bunch from many bunches is kicked, we hope other bunches have almost no oscillation.





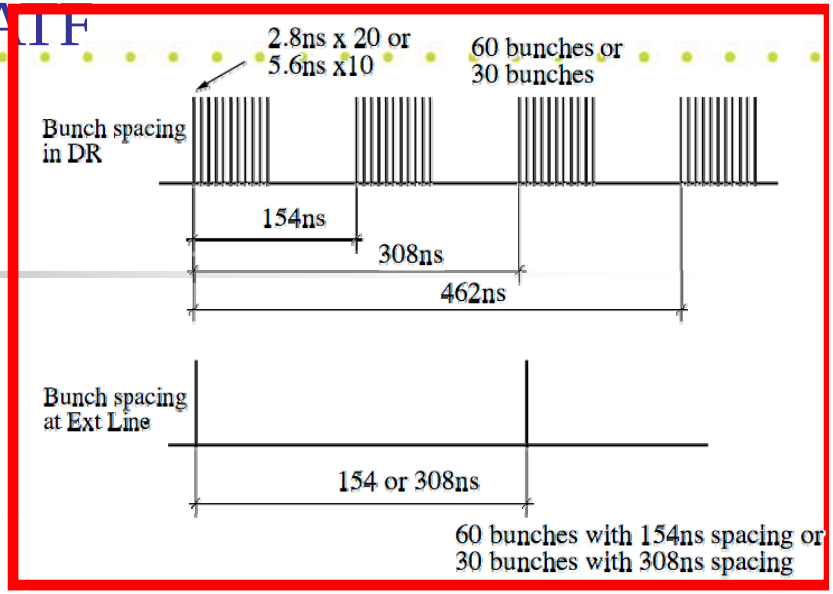


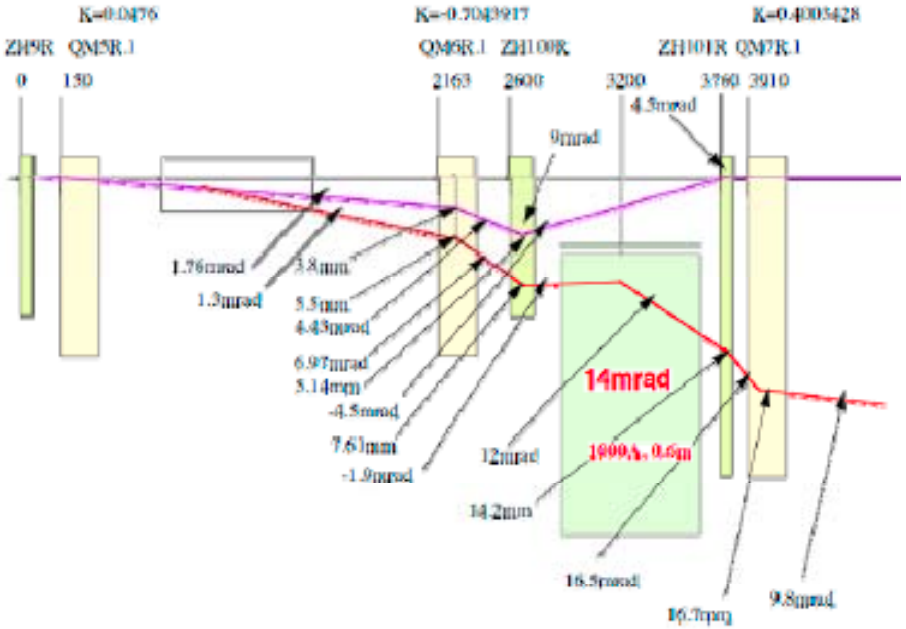
The preliminary results shows the different oscillation amplitude of the tune-X and the tune-Y for the 1st and 2nd bunches at just after injection.

Multi-bunch Beam extraction design for

Future Kicker Tests at ATF

Multi-bunch Beam extraction by using strip-line kickers and pulse bump orbit system was designed, which can extract up to 60 bunches with 154ns bunch spacing. The space for installation of the strip-line kicker is not enough at the ATF septum region. So the kick angle of the strip-line kicker is not enough to make the beam extraction orbit. We need a small septum.





Circulate Beam orbit

Extracted Beam orbit

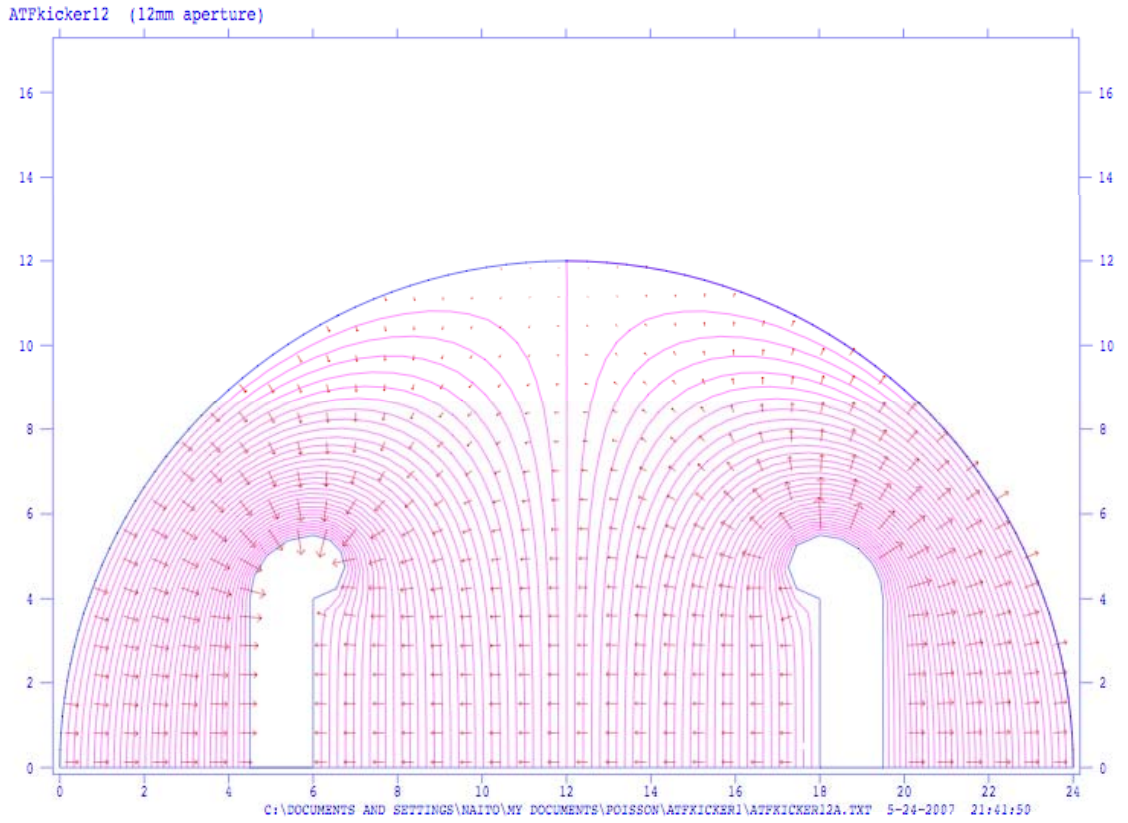
A new design uses slow bump magnets and a thin septum magnet to help making the extraction orbit. This design makes a bump orbit after beam damping, then each beam is extracted bunch-by-bunch by the strip-line kickers.

New septum and a "slow" orbit bump would allow fast extraction using two 30 cm strip lines, driven by ±10 kV pulsers.

Designed by T.Nato(KEK)

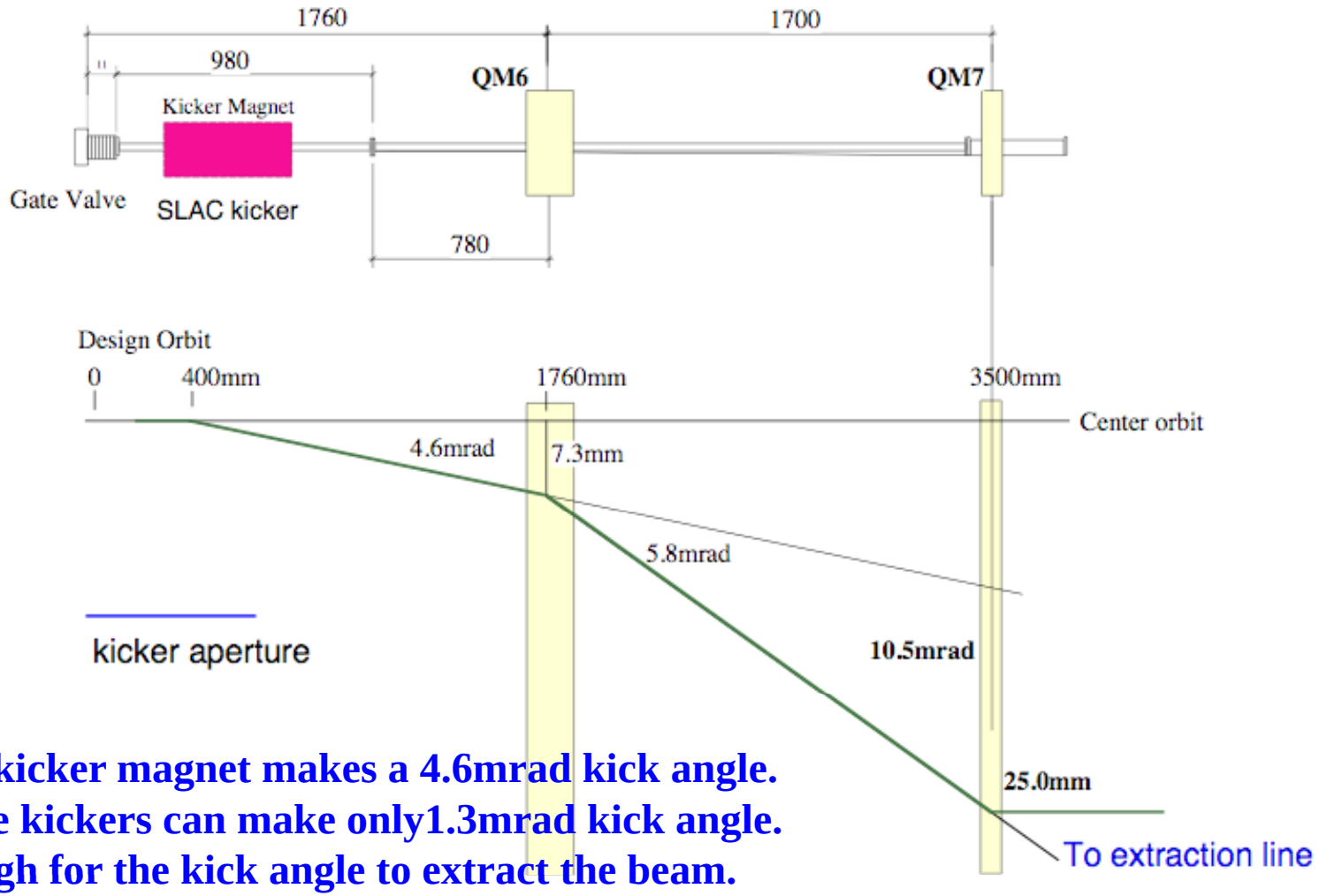
Electric and magnetic field lines of the strip-line electrode

Electrode distance:12mm
Chamber diameter : 24mm
Impedance :50ohm
Max field at 10kV :
4.7MV/m



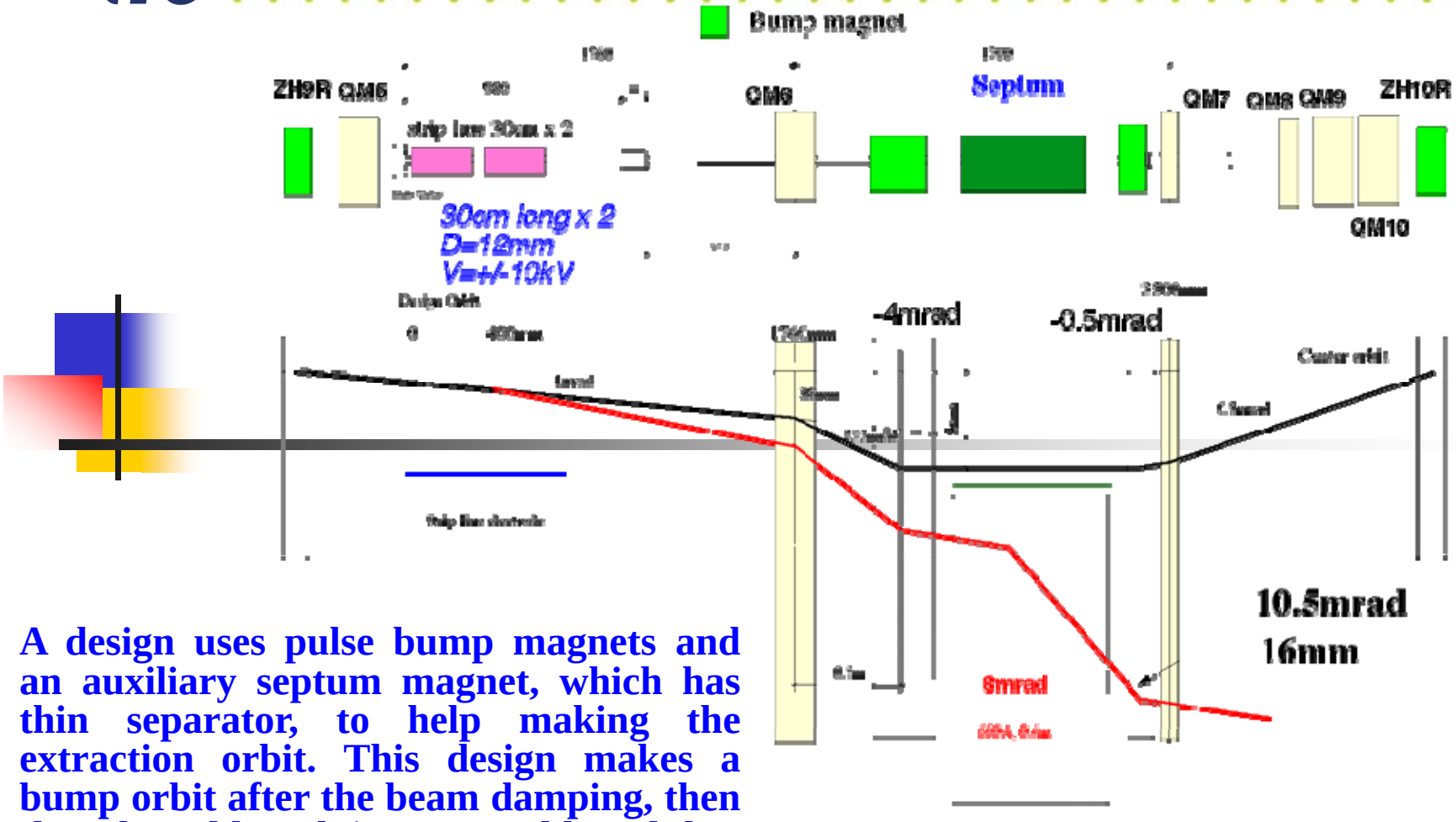
Replacement from kicker magnet to strip-line kicker

Present layout



A 60cm long kicker magnet makes a 4.6mrad kick angle.
Two strip-line kickers can make only1.3mrad kick angle.
It is not enough for the kick angle to extract the beam.

Beam extraction design with two strip-line kickers

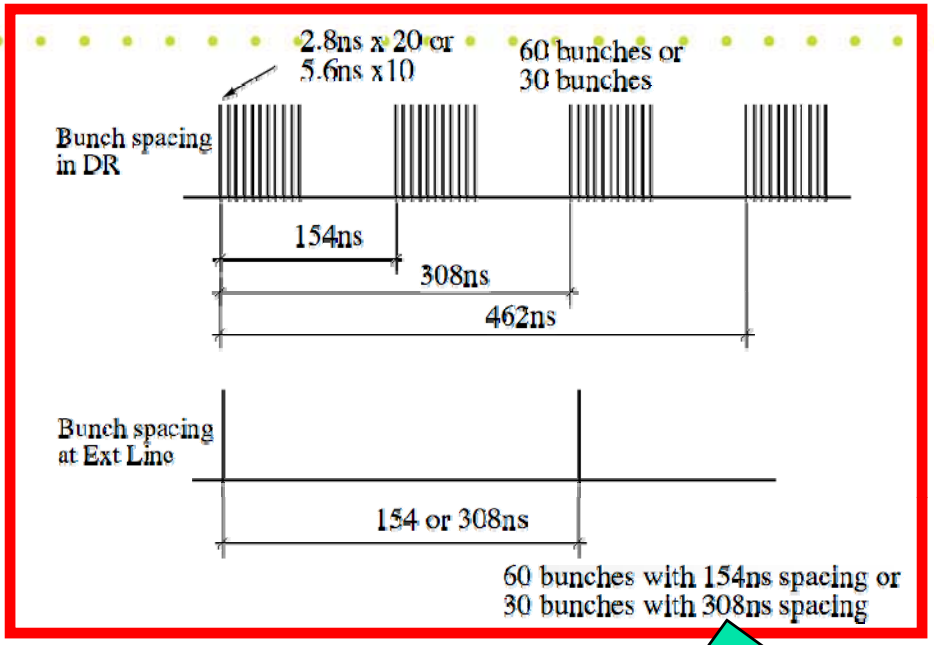


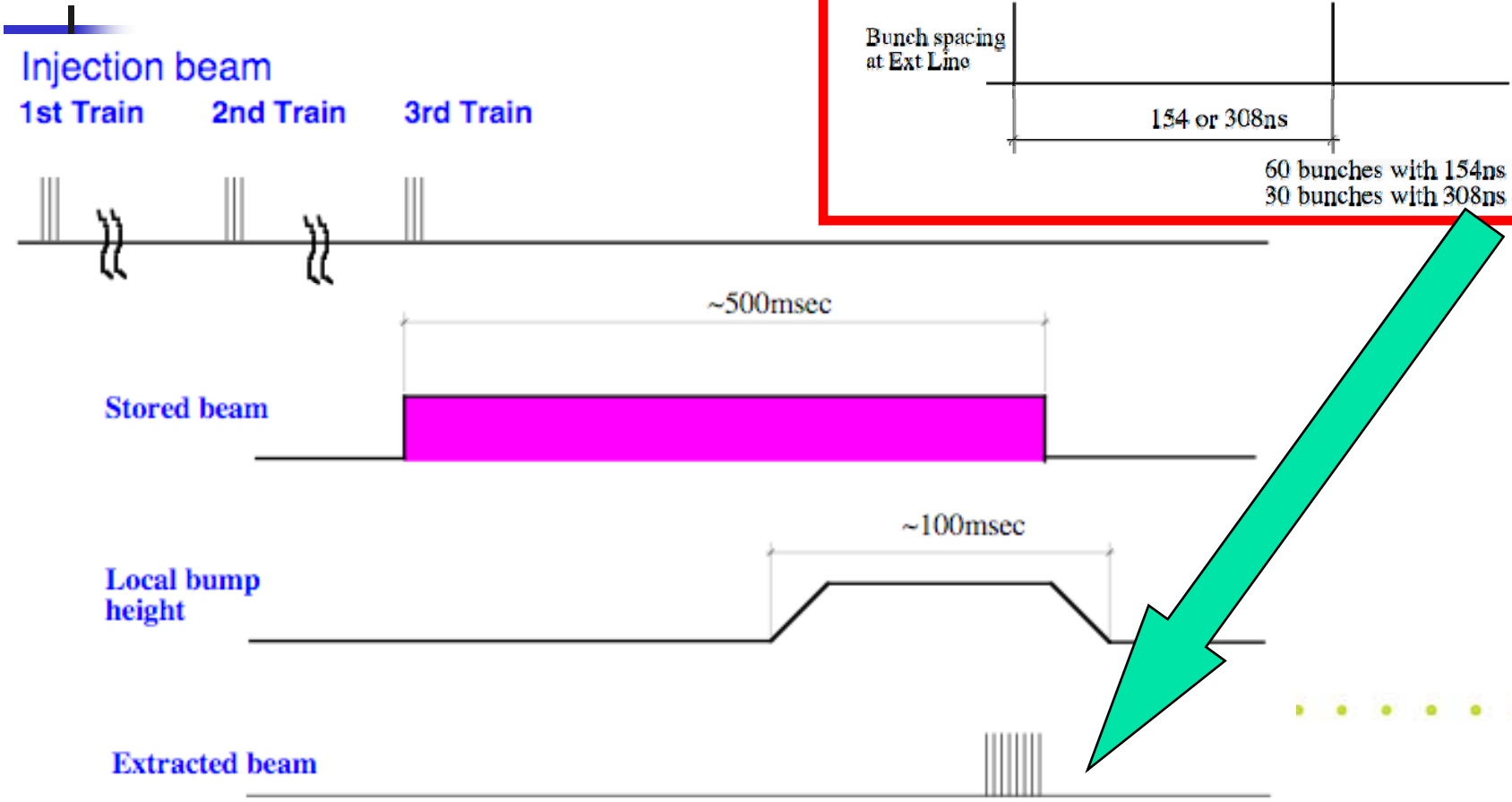
A design uses pulse bump magnets and an auxiliary septum magnet, which has thin separator, to help making the extraction orbit. This design makes a bump orbit after the beam damping, then the selected bunch is extracted bunch-by-bunch by the strip-line kicker.

This is not optimum and starting point for the design consideration.

Timing chart of 60(30) bunches beam extraction

The bump orbit is gradually increased 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) spacing.





Detail of power supply control

To avoid the beam loss at the injection timing by the bump orbit, the current control starts from 200ms after injection, which correspond to about three damping time. The current ramp needs 120ms to keep the beam orbit. The beam is extracted at the flat-top of the current.

Beam Injection

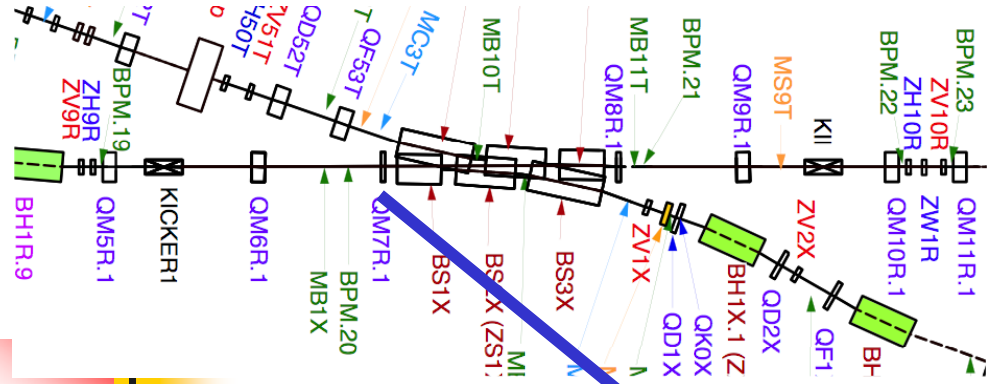
Bump orbit start

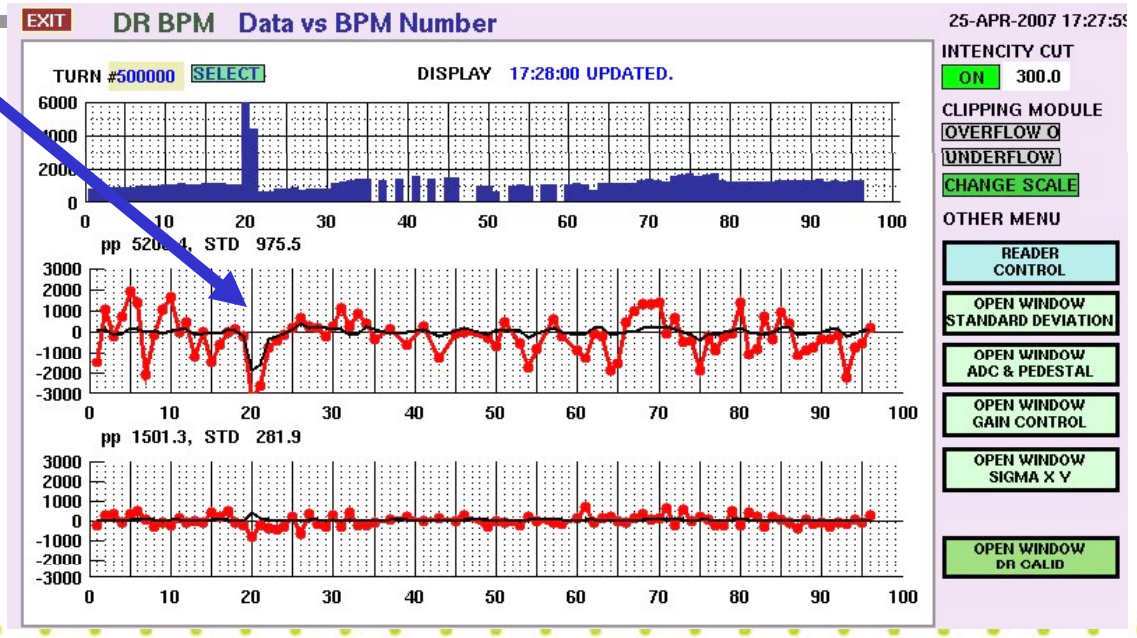
Current control

Magnet current

100ms/div

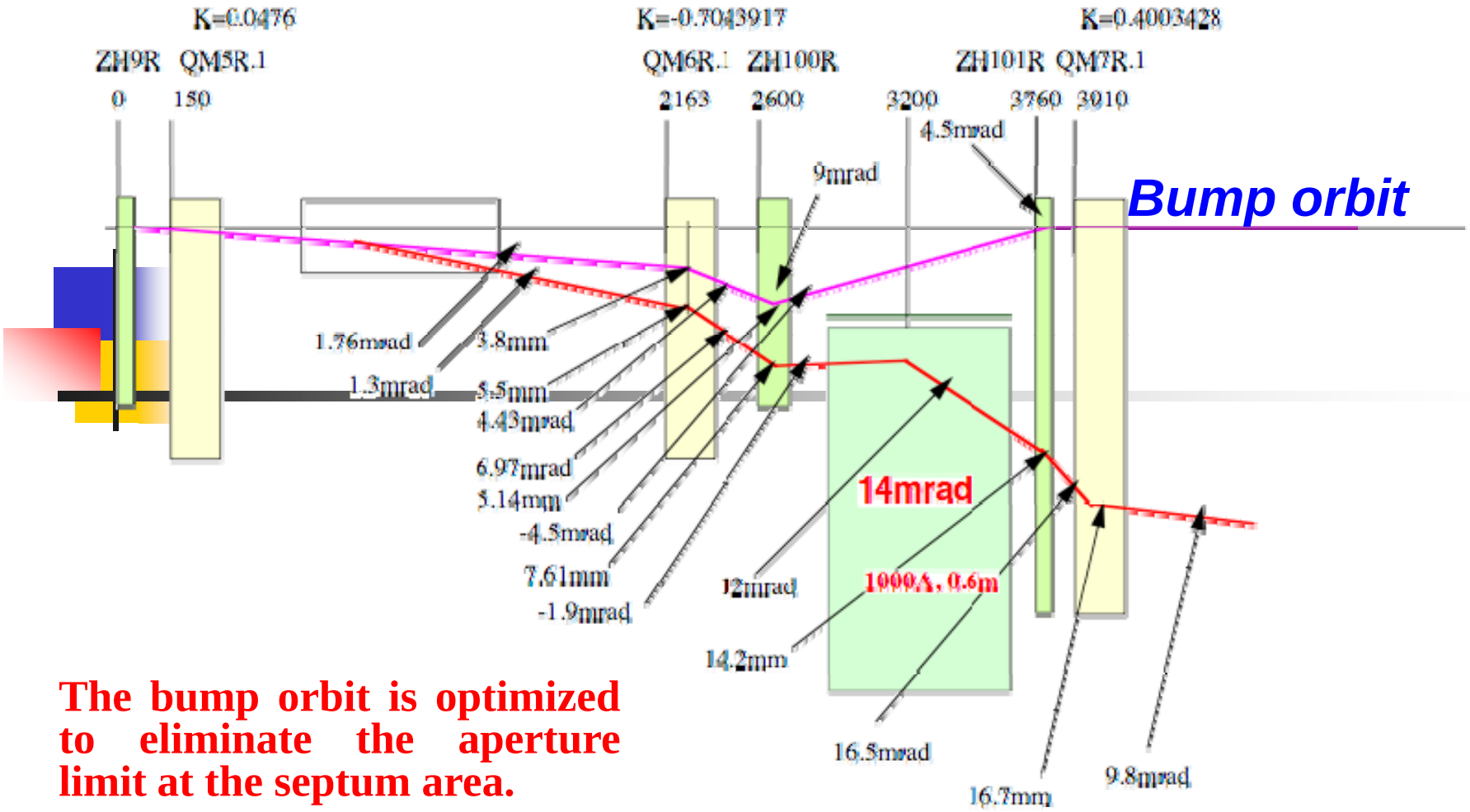
Local bump by using present magnets and DC power supplies





The aperture survey was carried out by using present magnets and DC power supplies. The required bump height is 5mm to separate the extraction beam and the circular beam.

Beam extraction design with two strip-lines



The bump orbit is optimized to eliminate the aperture limit at the septum area.

Required magnet parameters

1. Magnets(not yet designed)
   - Steering magnets
     - Bending angle: 9mrad(max)
     - Effective length 100mm
     - 0.4T(max)
   - Septum magnet
     - Bending angle: 14mrad
     - 1000AT, 0.6m, 1 turn coil
2. Power supplies
   - Steering magnets - 50A(MAX), 10V(pulse)
   - Septum magnet - 1000A, 1V(DC)

Proposed Schedule

- **4 sets of 10kV fast pulsers order and test — until end of 2007**
- **Fabrication strip-line electrodes — until end of March 2008**
- **Fabrication bump magnets and pulse PS — until end of 2007**
- **Pulse bump magnet test — until end of March 2008**
- **Fabrication Septum magnet — until end of June 2008**
- **Installation strip-line electrodes and septum — Summer 2008**
- **Beam test — Autumn 2008**

Strip-line electrode from LNF and fast pulse power supply from LLNL and SLAC in 2008 or 2009 will be expected.

Kicker Specifications

$$V \times L = \frac{2}{k} \frac{A_{x,\max}}{\gamma} \frac{E}{e}$$

The kickers will consist of strip-lines fed by ultra-fast, high-voltage pulsers. The integrated voltage required is determined by the acceptance specification:
where V is the voltage between the strip-lines, L is the strip-line length, k is a geometry factor (~ 0.7) determined by the strip-line shape, $A_{\max}$ (~ 0.09 m for injected positrons) is the maximum betatron amplitude, E is the beam energy and γ is the relativistic factor.

Integrated voltage	> 132 kV-m
Rise and fall times	< 3 ns
Repetition rate	5.5 MHz
Pulse length	970 μs
Stability	< 0.1%

Kicker Systems

- There is a continuing R&D program to develop a pulser that meets the specifications for amplitude, rise and fall time, repetition rate, and stability.
- Several technologies look promising, including:
  - fast ionization dynistor (FID);
  - drift step recovery diode (DSRD);
  - "inductive adder" (MOSFET).
- There is a commercial FID device available that comes close to meeting the specifications.
  - A prototype with modified architecture, which could meet most of the ILC specifications, is in development; a version for bench testing is expected by the end of 2009.
- Modification of ATF extraction system to allow fast extraction of individual bunches from a train is planned for late 2008.