ATF Results and ATF-II Plans

Ongoing unique test facility for ILC with a low emittance beam.

Junji Urakawa (KEK)

for

the ATF International Collaboration

ATF
Accelerator Test Facility

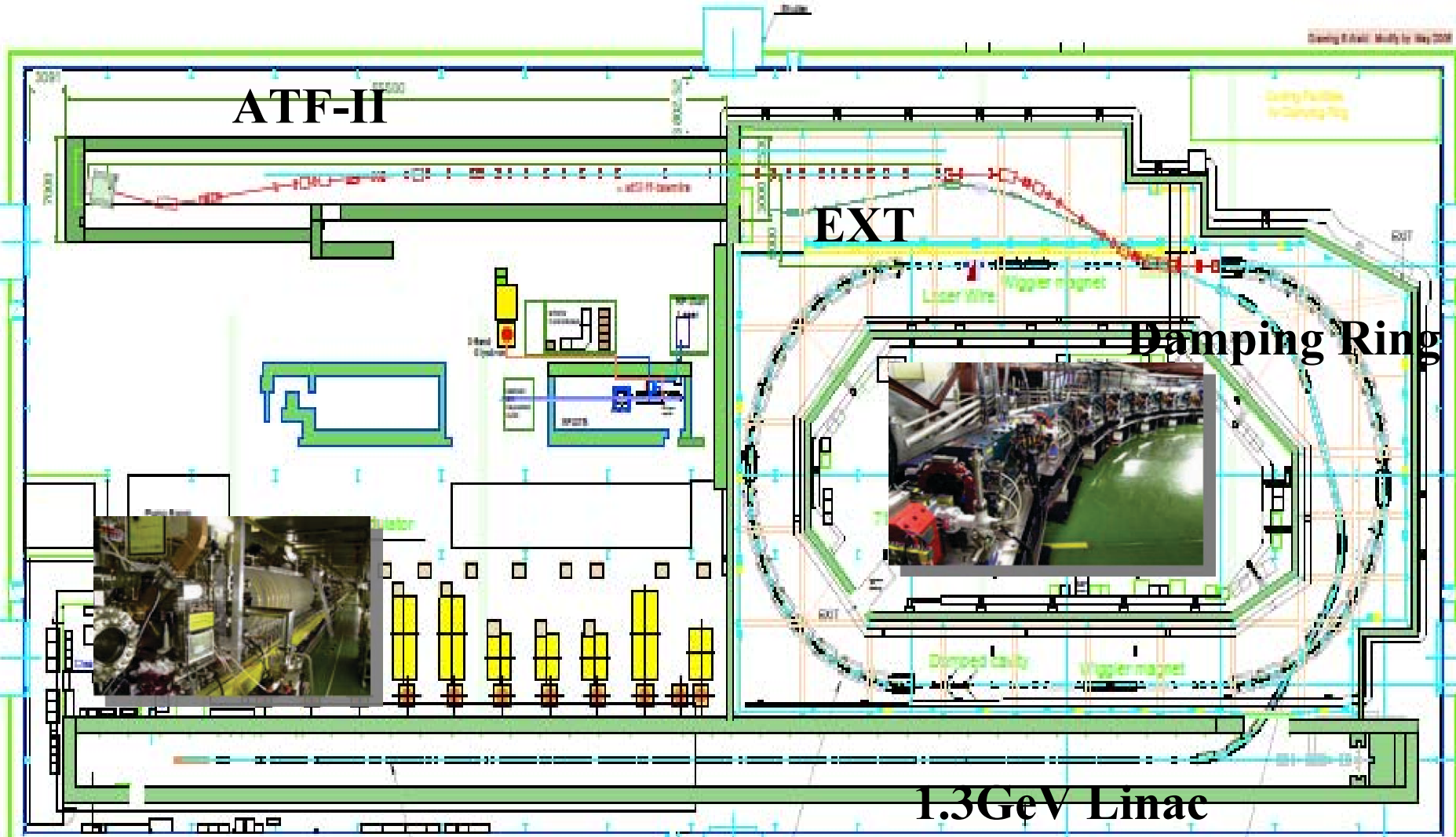


Photo-cathode RF Gun which can generate 20 bunches/pulse.

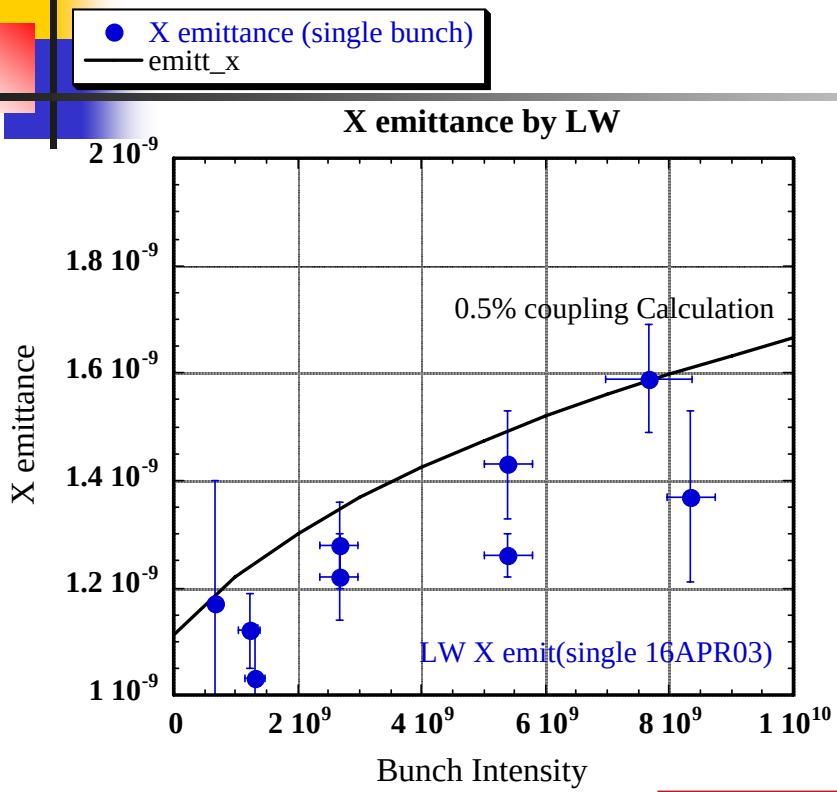
Achievement of ATF

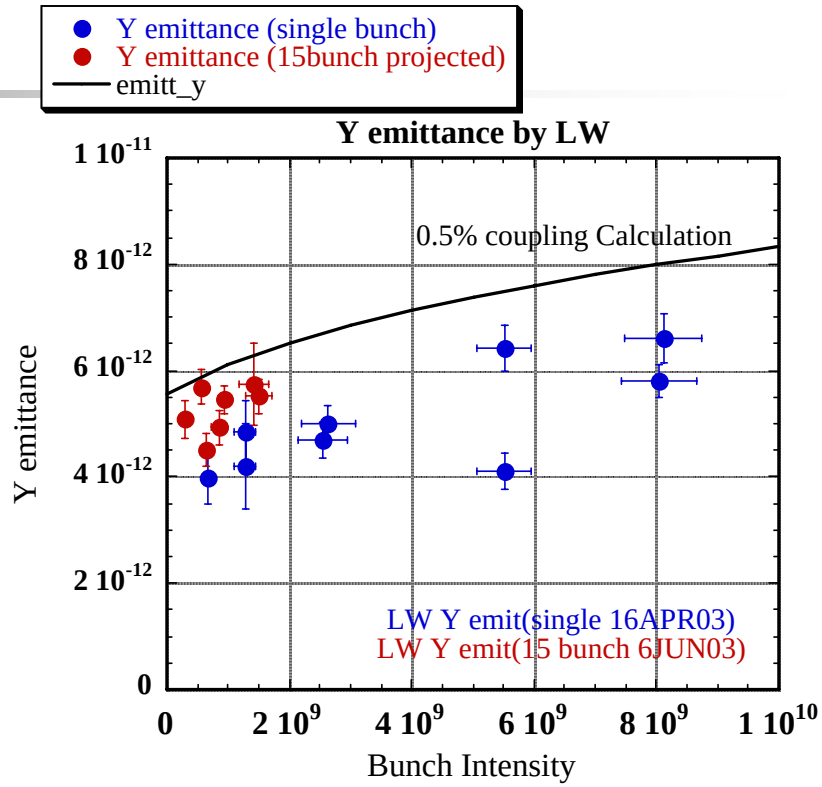
1. **Emittance in Damping Ring.**

   1nm-rad horizontally, 4pm-rad vertically at low intensity

2. **ILC Fast kicker development.** **3ns fast rise time**
3. **DR BPM upgrade program.** **<1micron resolution. By SLAC and FNAL et al. collaboration**
4. **Multi-bunch turn-by-turn monitor.** **For FII study, kicker**
5. **nm BPM experiment.** **17nm resolution achieved. By SLAC, LLNL, KEK et al.**
6. **FONT4 experiment.** **digital feedback. By Oxford et al.**
7. **Laser Wire at EXT-line.** **fast scan wire for ILC. By RHUL et al.**
8. **ODR BSM.** **Completed by KEK and Tomusk University.**

Emittance measured by CW Laser wire





< 0.5% y/x emittance ratio

Y emittance =4pm at small intensity

VOLUME 92, NUMBER 5 PHYSICAL REVIEW LETTERS week ending 6 FEBRUARY 2004

Achievement of Ultralow Emittance Beam in the Accelerator Test Facility Damping Ring

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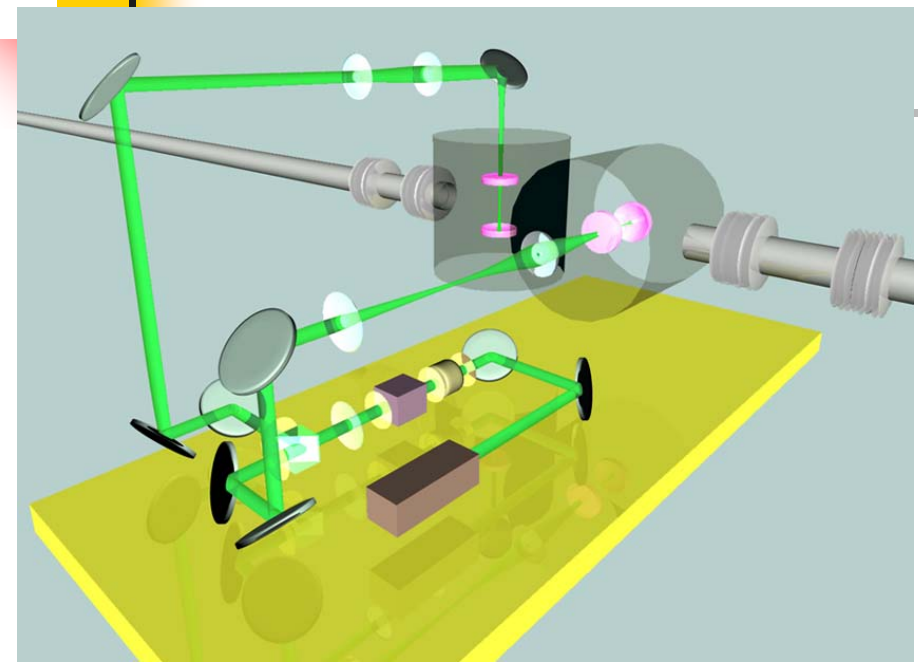
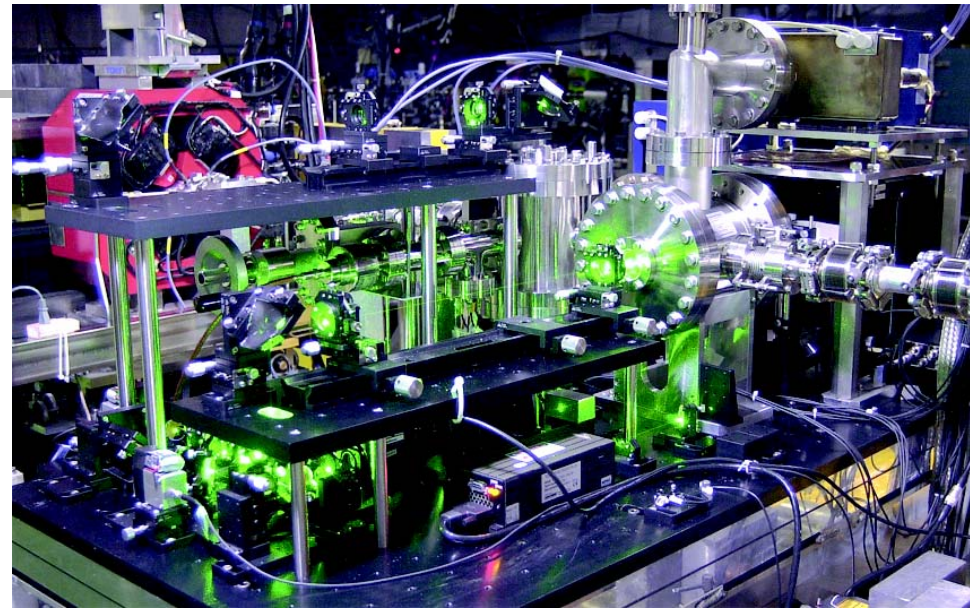
Laser wire beam size monitor in DR

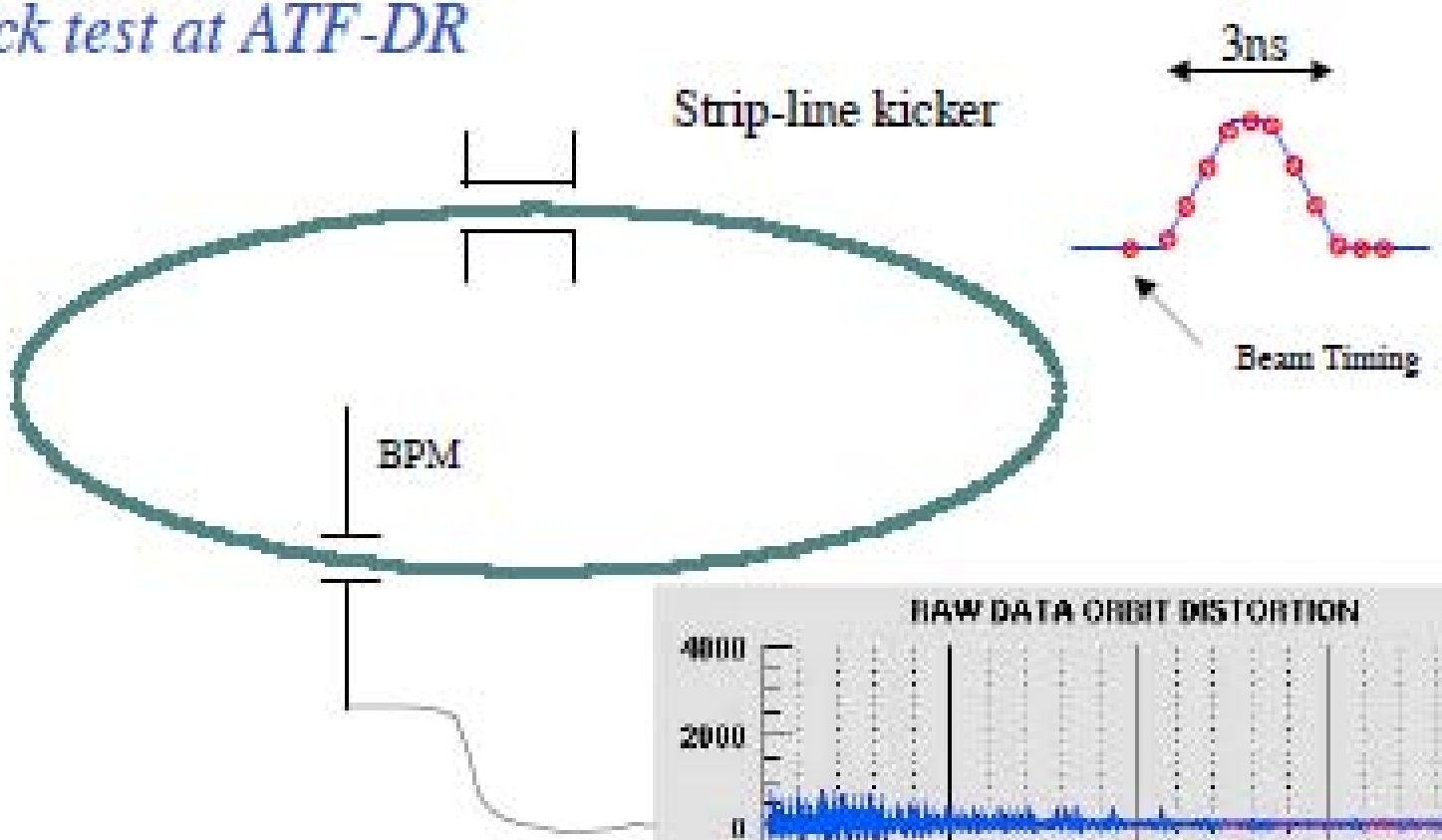


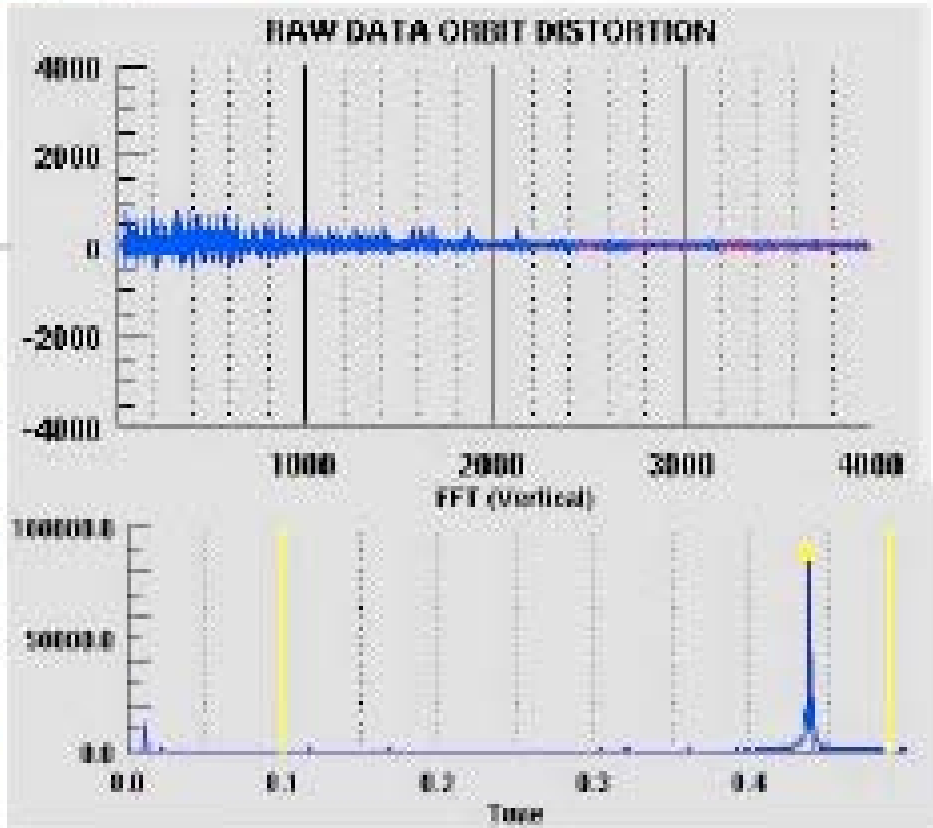


300mW 532nm Solid-state Laser fed into optical cavity

14.7μm laser wire for X scan
5.7μm for Y scan
(whole scan: 15min for X, 6min for Y)

Beam kick test at ATF-DR



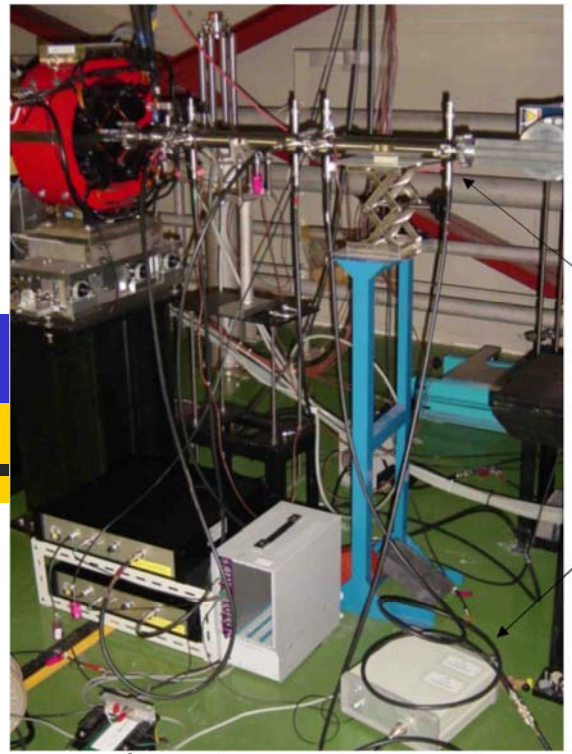


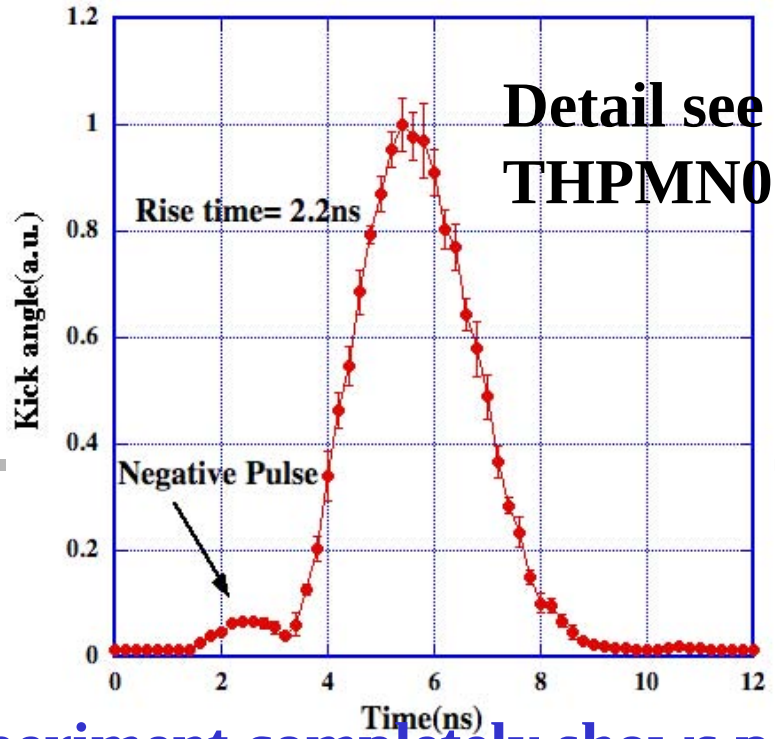
The kicker pulse is applied to the strip-line electrode at just the time of the beam goes through the electrode.

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

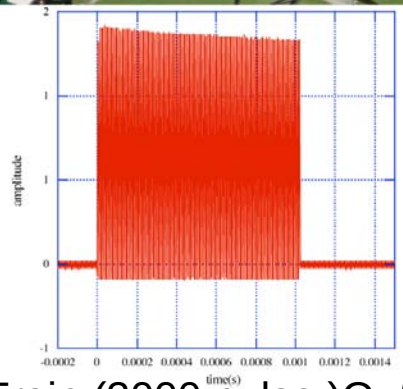
The kick effect is measured by scanning the pulse timing.

Beam Kick test of ILC Fast kicker (KEK, LLNL, SLAC, DESY, FID Co.)





Detail see poster THPMN028



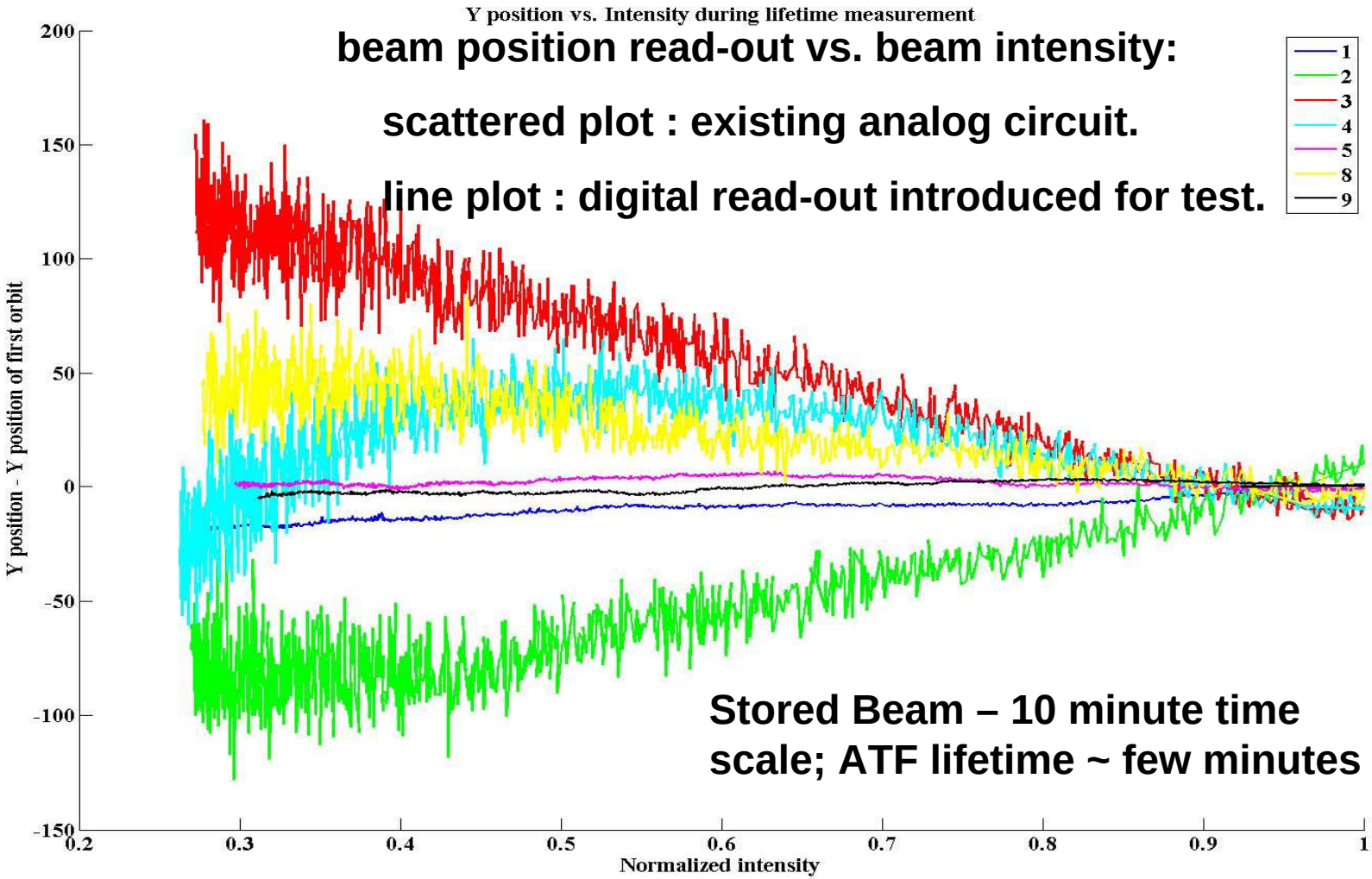
Pulse Train (3000 pulse)Output from FID Pulser

This experiment completely shows perfect kick timing control.

rise time improvement
by using waveform compensator.

3 ns -> 2.2 ns

DR BPM resolution improvement by digital read-out system (SLAC, FNAL, KEK)



beam position read-out vs. beam intensity:

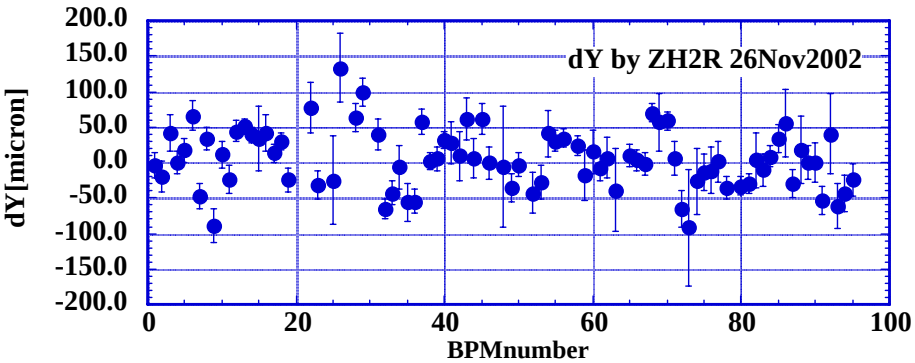
scattered plot : existing analog circuit.

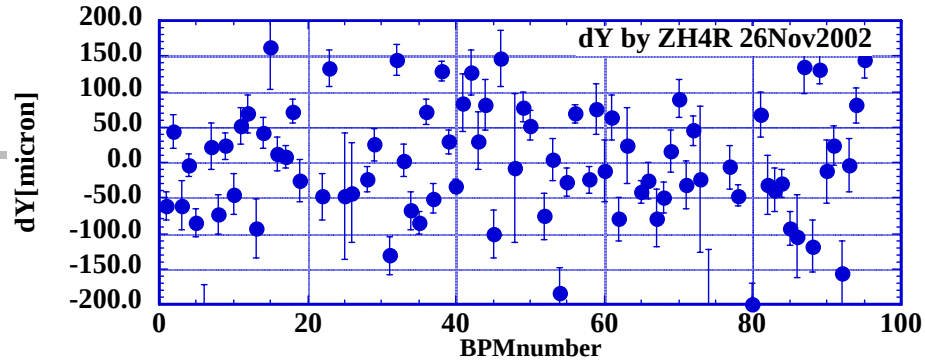
line plot : digital read-out introduced for test.

Stored Beam – 10 minute time scale; ATF lifetime ~ few minutes

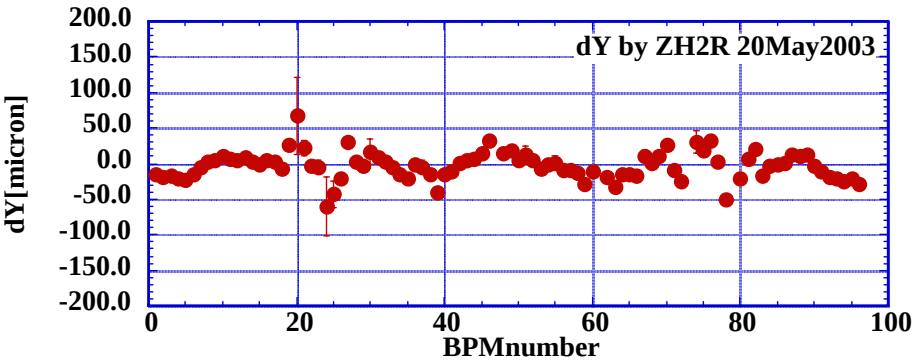
X to Y coupling Improvement

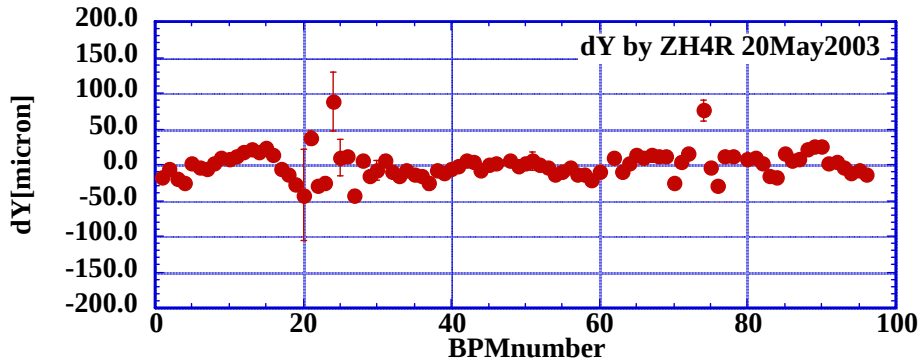
20μm BPM Resolution with old circuit (1997-2002)





3μm BPM Resolution with present circuit (2003-2008)



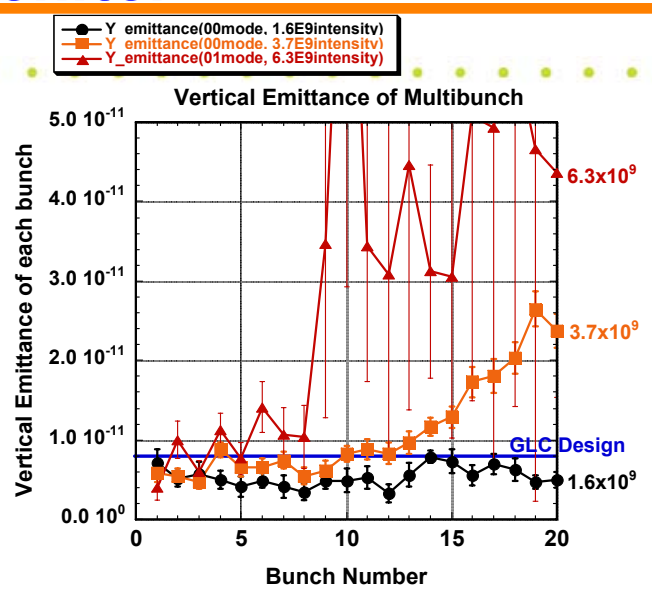


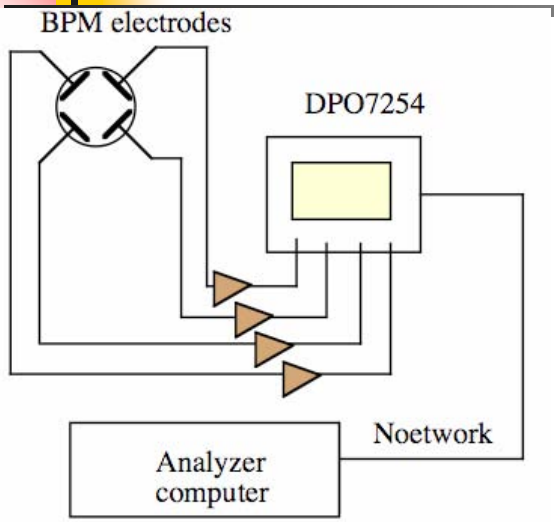
Upgrade of BPM Resolution (~ 0.1μm) with new circuit by SLAC and FNAL. Surely, we will achieve 2pm-rad. Possibly 1pm.

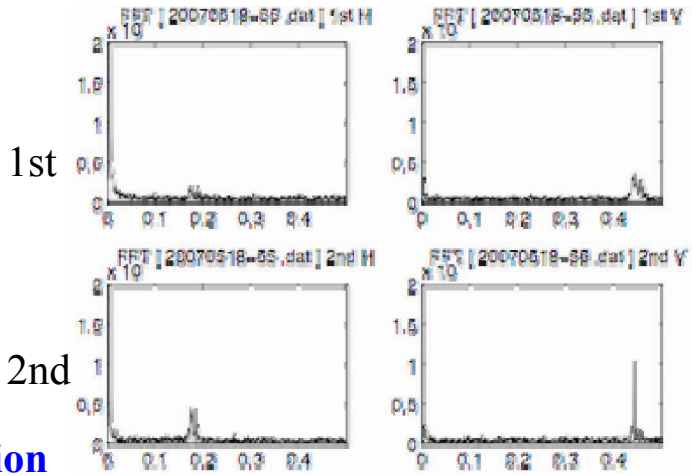
Multi-bunch Turn-by-turn monitor

T. Naito (KEK)

The beam blowup at tail bunches was measured by the laser wire in ATF, which is assumed come from FII effect. In order to observe the individual beam oscillation in the multi-bunch beam, multi-bunch turn-by-turn monitor is developing. 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.



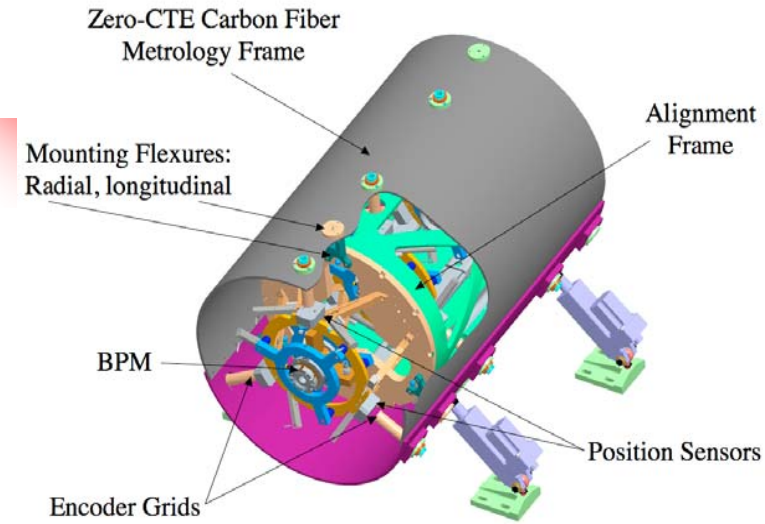




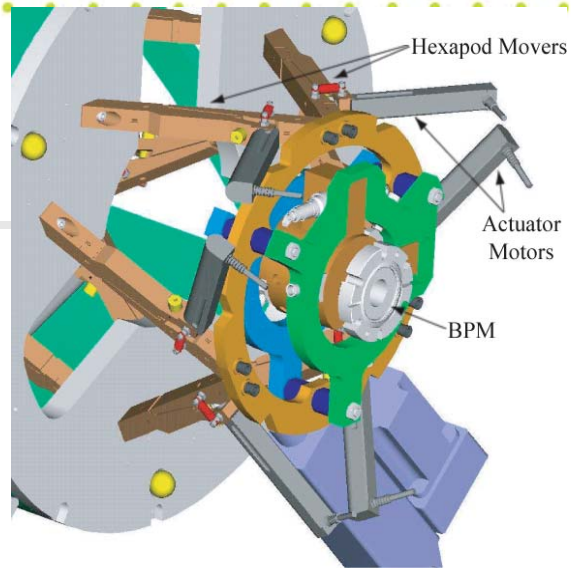
The preliminary results shows the different oscillation amplitude of the tune-X and the tune-Y for the 1st and 2nd bunches at just after injection.

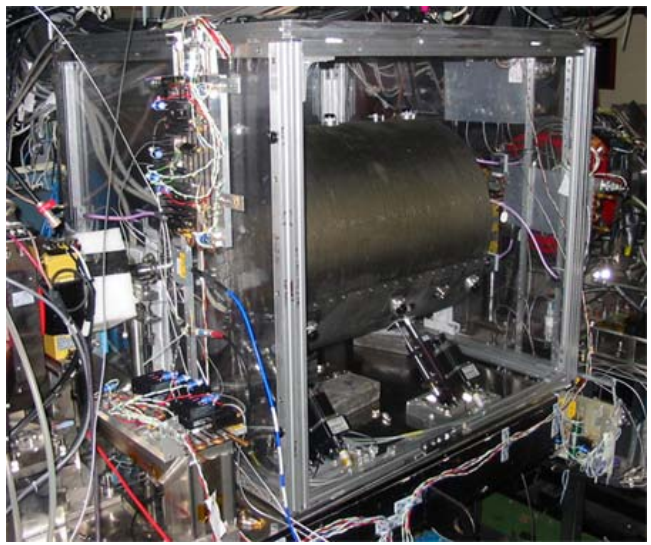
nm resolution BPM

(SLAC, LLNL, UK-University, KEK)

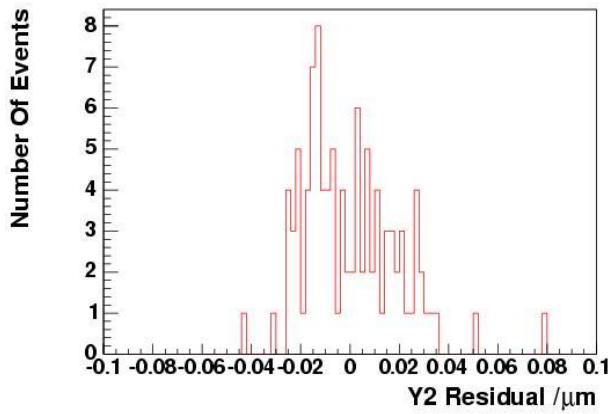


In detail see Poster FRPMS049





ATF single bunch beam test

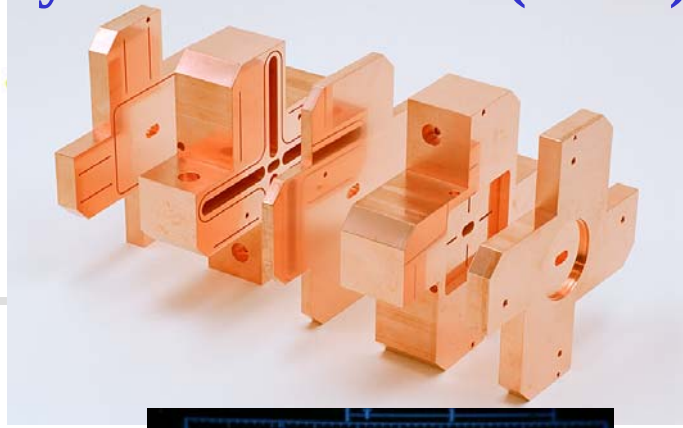


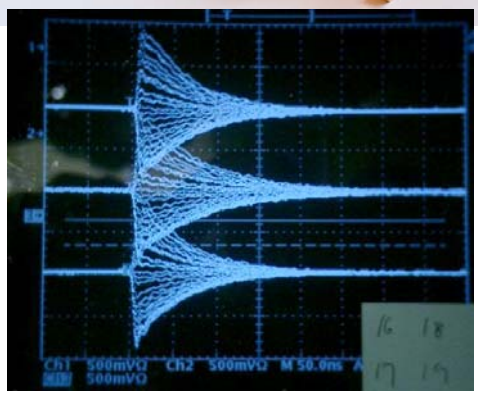
16nm resolution achieved

ATF2 IP-BPM

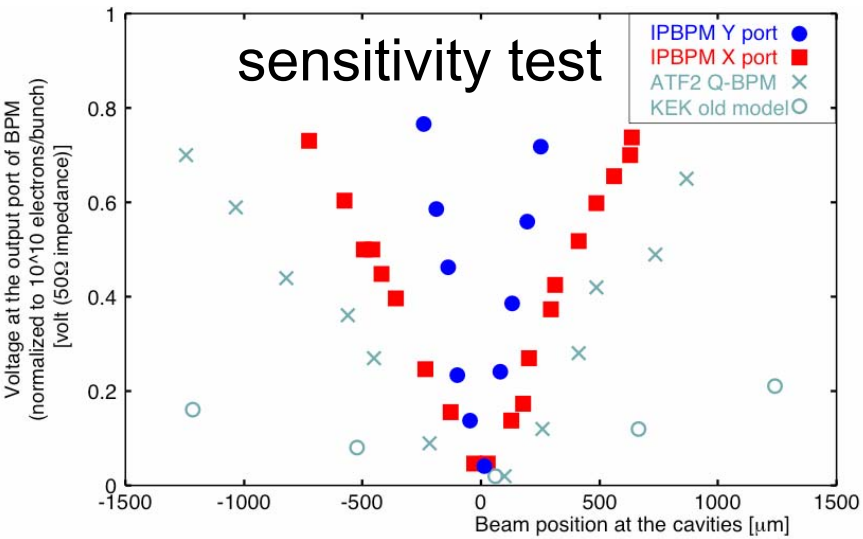
By Yosuke Honda (KEK)

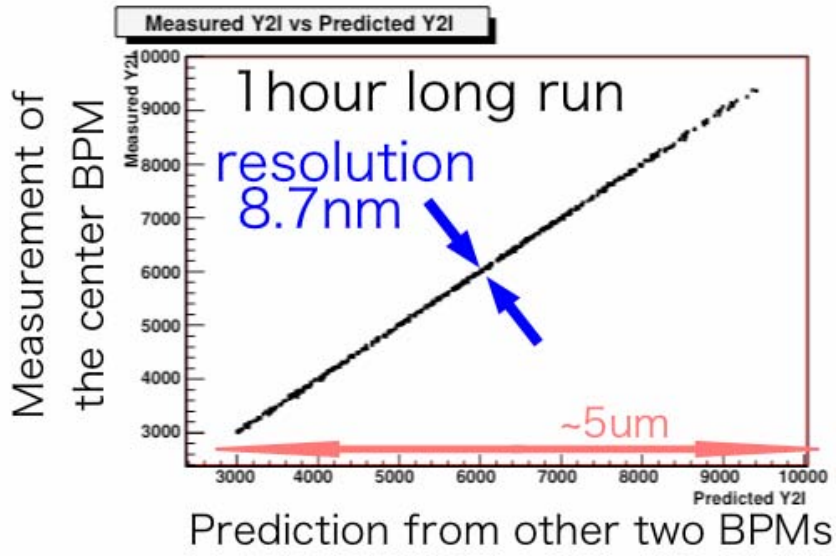
- goal
  - measure beam jitter at the focal point of ATF2
  - produce a feedback signal for beam stabilization
- requirements
  - ultimate high resolution (a few nm)
  - less sensitivity for beam angle
- special cavity BPM
  - rectangular shape (X:5.7GHz, Y:6.4GHz)
  - thin cavity for angle signal reduction
  - small beam tube for high sensitivity
- status
  - various properties were checked with beam (position sensitivity, angle sensitivity, etc.)
  - 8.7nm reslution was achieved by 3-bpm measurem





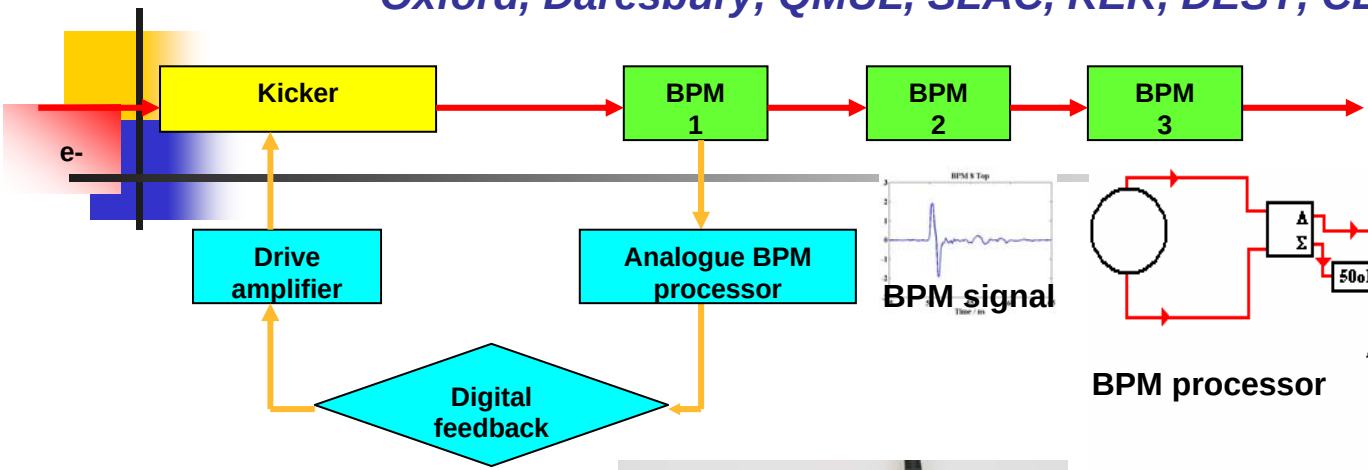
Refer FRPMN054



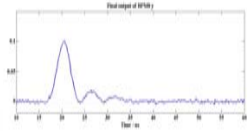


FONT4 : Digital IP feedback R&D at ATF

Oxford, Daresbury, QMUL, SLAC, KEK, DESY, CERN et al.



output signal



BPM signal

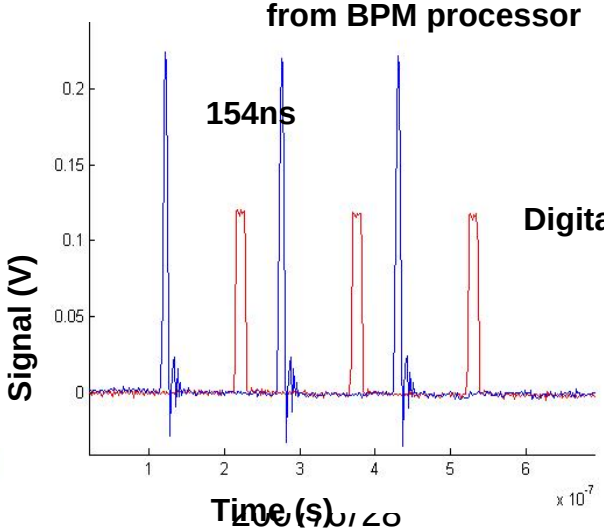
BPM processor

In detail
See poster
MOPAN108

signal pass latency : 25ns
BPM processor:7ns
Digital board:68ns
drive amplifier:40ns ***total:140ns***

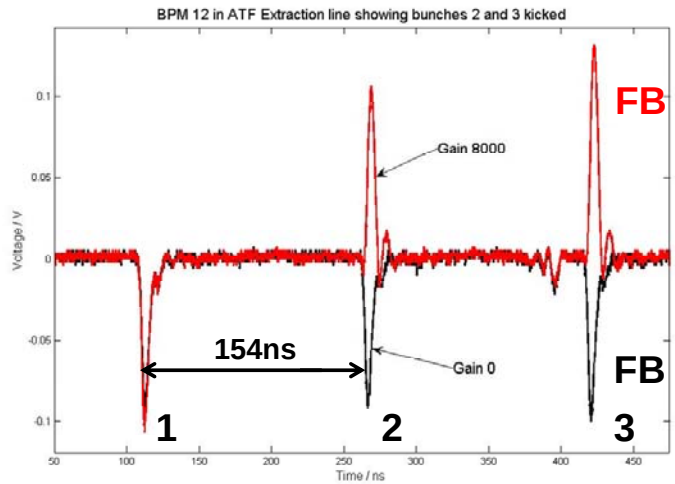
Digital Board development

Analogue input from BPM processor



Digital processor output

Beam Position



FB on

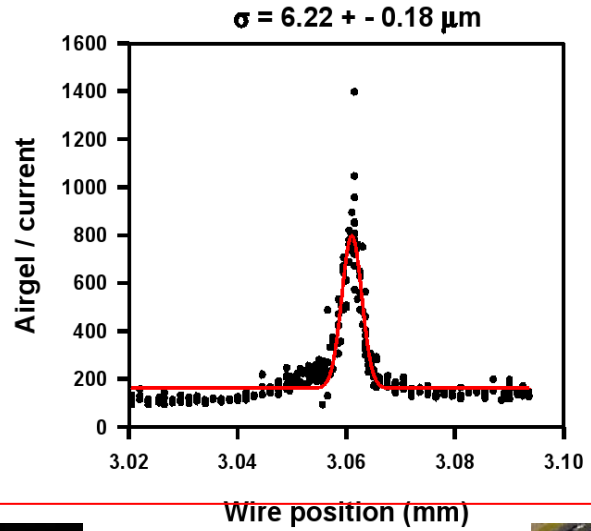
FB off

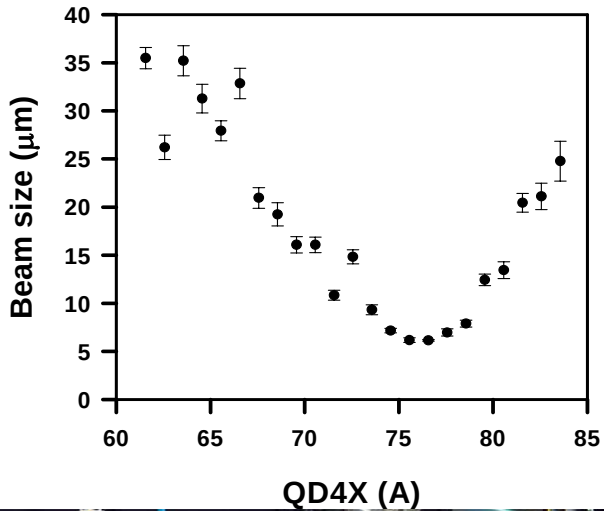
Laser-wire at ATF-EXT

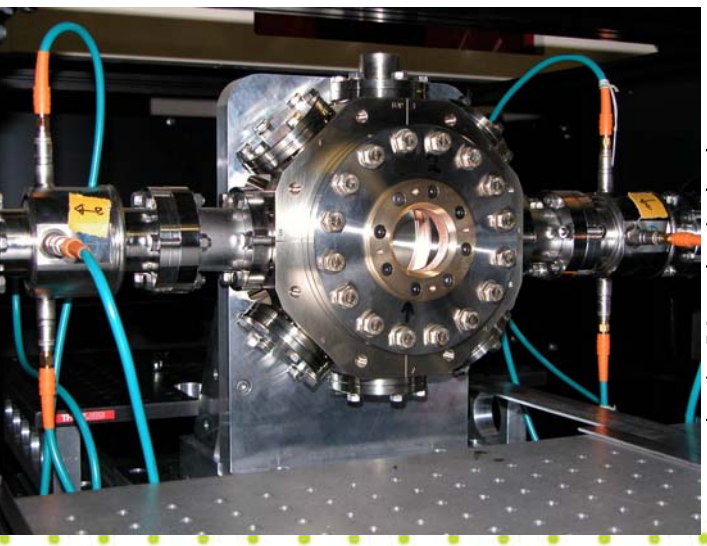
By Grahame Blair (RHUL) et al.

6min 43s

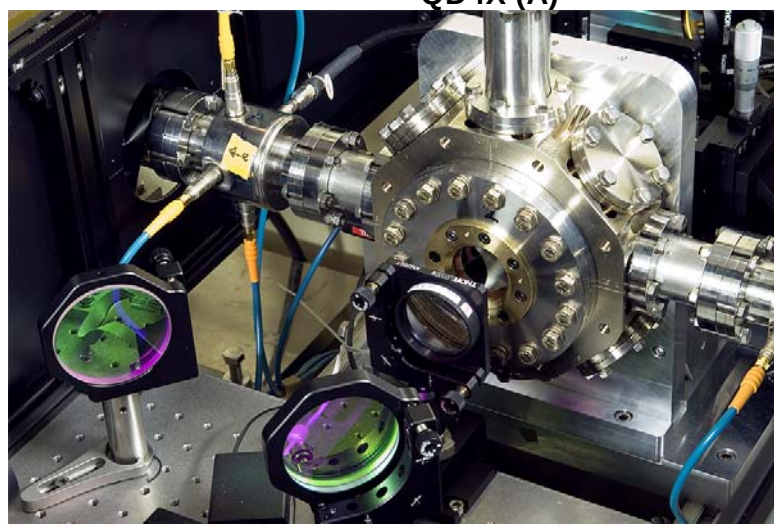
In detail see poster FRPMN093, and hear contributed papers THOAC01.





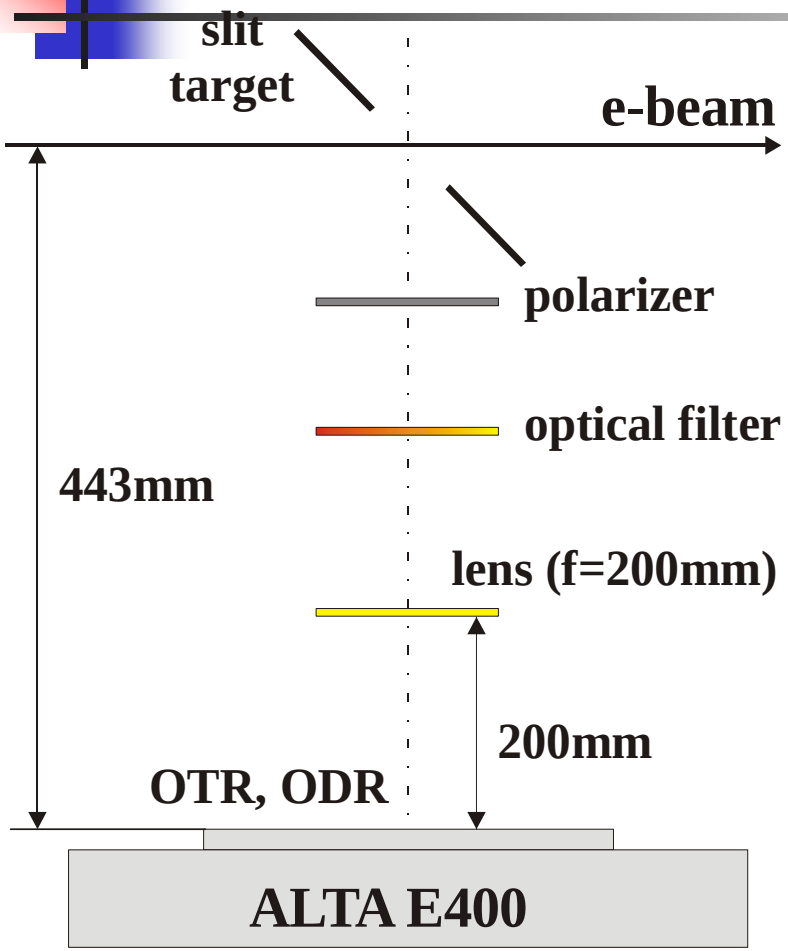


Modify optical lens to realize sub-micron laser waist size.

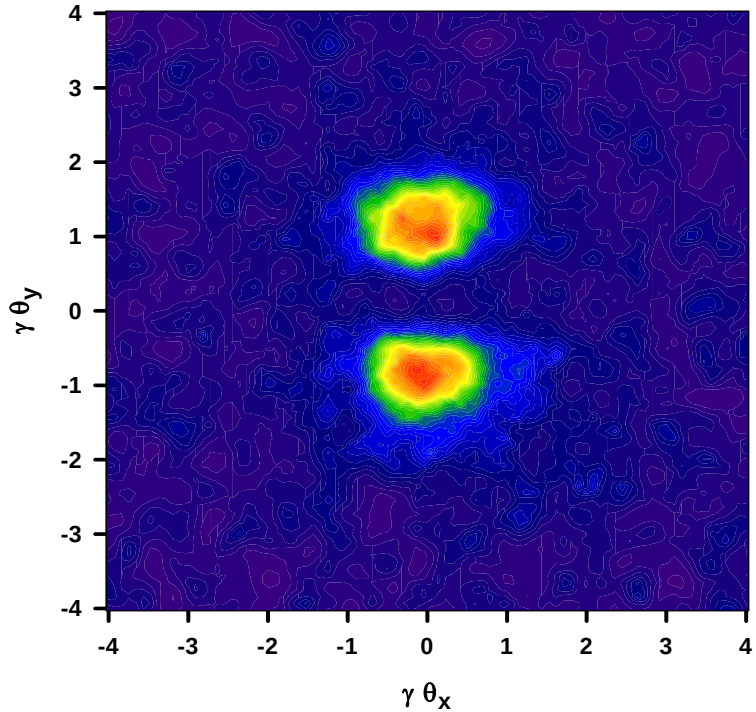


Optical Diffraction Radiation (ODR) beam size monitor (BSM) at KEK-ATF

Experimental layout



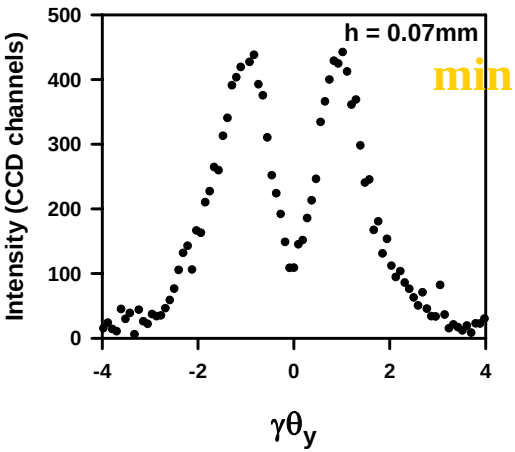
Typical CCD image of ODR vertical polarization component

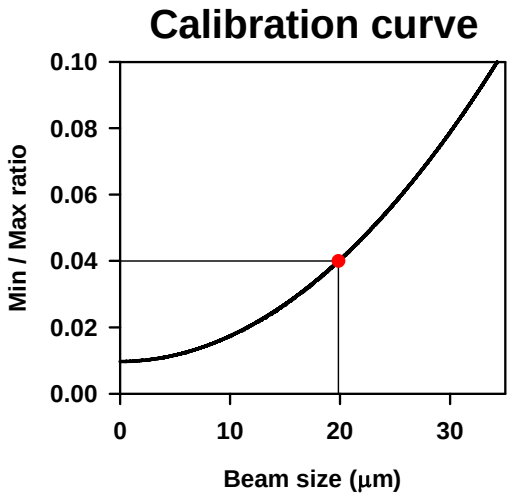


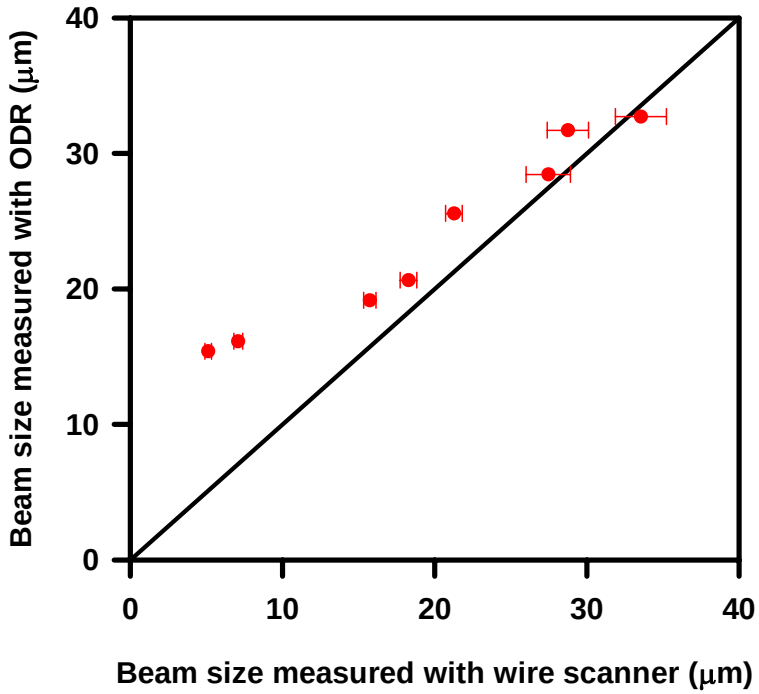
Single-short beam size measurements using ODR

max

Beam size was changed by a quadruple magnet







Plans

In the future we plan to integrate the ODR monitor into the Laser Wire chamber at the ATF2 in order to cover the beam sizes in the range 15-100μm. We also consider synchronization of the ODR measurements with ATF main control system to be able to acquire Beam Position Monitor and current data. In this case a real single shot beam size measurement with ODR will be possible.

Future plans

- ATF-II project
- Fast ion instability study with flat beam
- Fast Kicker R&D
- Feed-forward to stabilize the extracted beam
- High Intensity pol. gamma-ray generation based on Compton Scattering

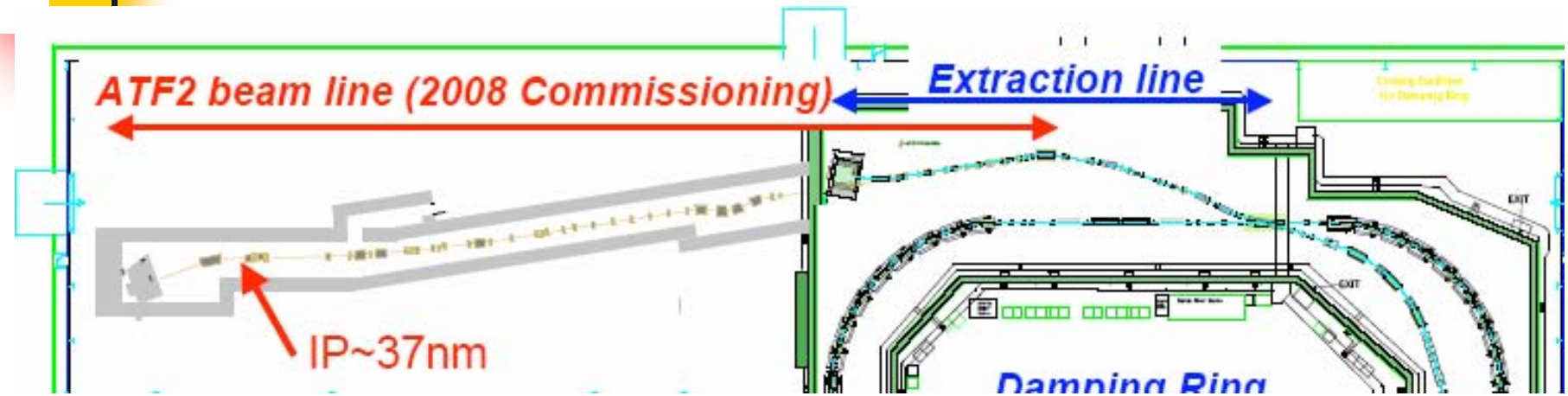
ATF-II Status for BDS R&D

ATF-II Project (37nm Final Focus beam line)

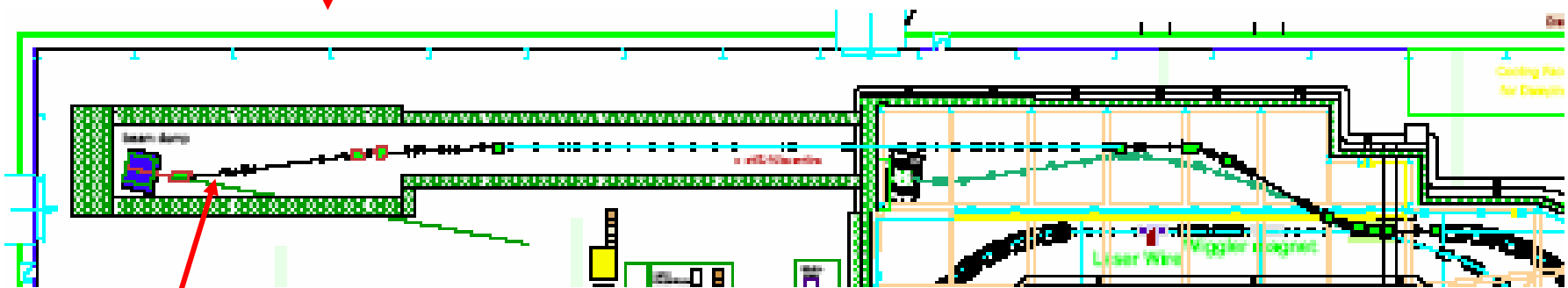
Status

- **Optics&beam line design fixed.**
- **Construction Schedule re-planed and fixed.**
- **Q-magnet from IHEP.**
- **Q-BPM from PAL.**
- **Electronics for Q-BPM from SLAC.**
- **High Availability power supply for magnet from SLAC,**
- **IP-BPM under beam test. (KEK, KNU)**
- **Laser Interference monitor upgraded. (Tokyo Univ.)**

ATF2 Beam line layout

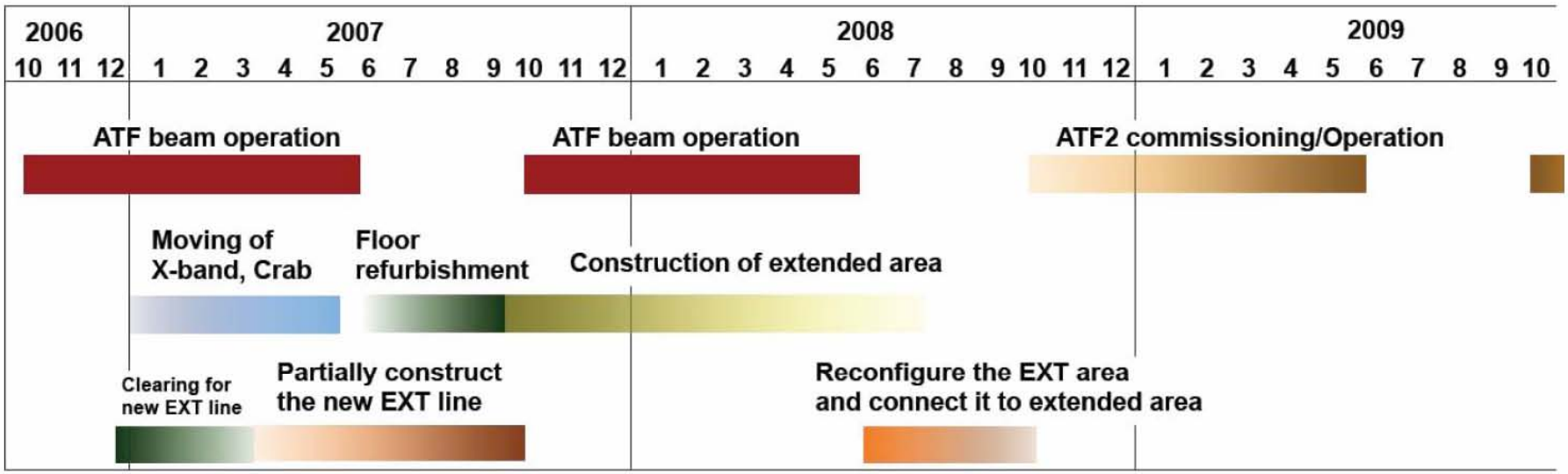


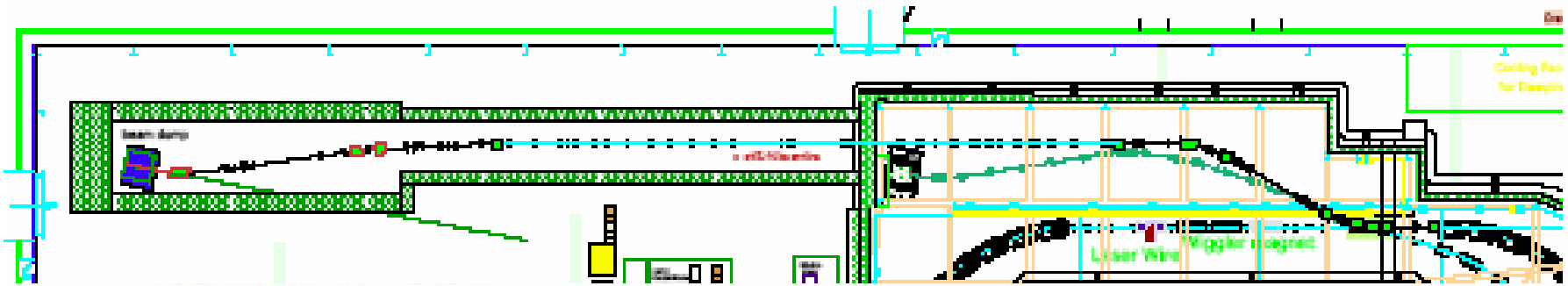
Optics & Lattice Design was fixed in June 2006.



IP ~37nm vertical size

ATF2 construction schedule

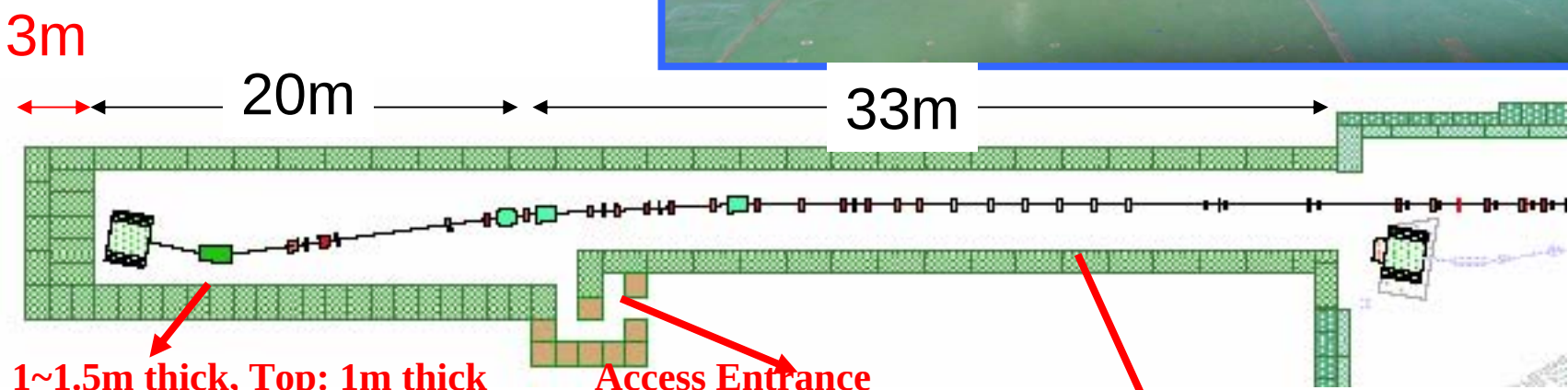




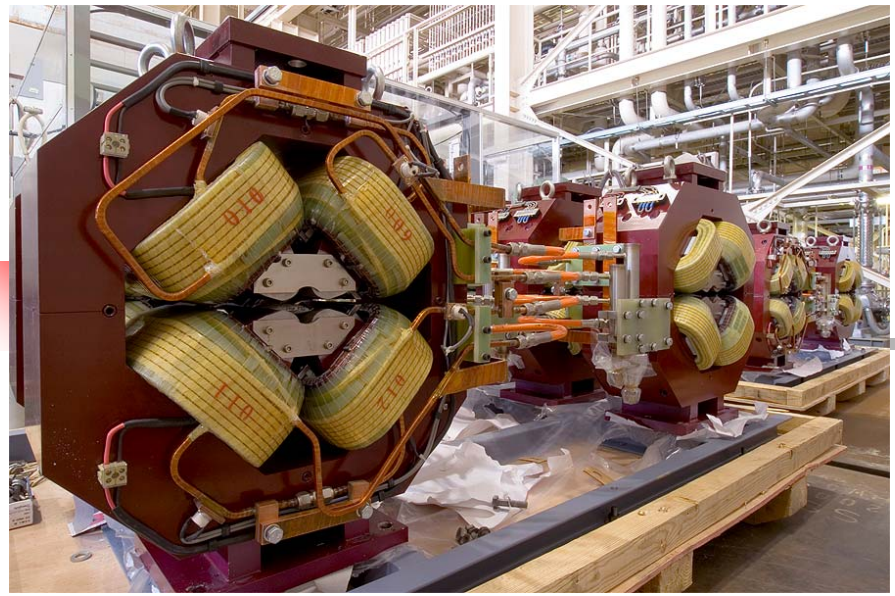
- ATF2 beam will come in October, 2008.

Area for ATF-II, 20/June/2007

Under refurbishment of the floor for ATF-II, it will be finished until the end of September.



ATF2 development Highlights

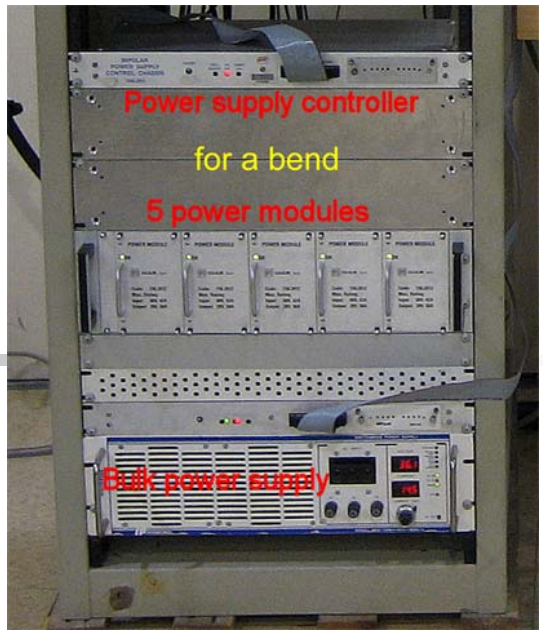


Q-magnet from IHEP
(IHEP, SLAC, KEK)
~ 30 magnets were delivered.

Cavity-BPM for Q-magnet from PAL (PAL, KEK)
~ 40 BPMs were delivered.

ATF2 development Highlights

In detail see poster MOPAS059.

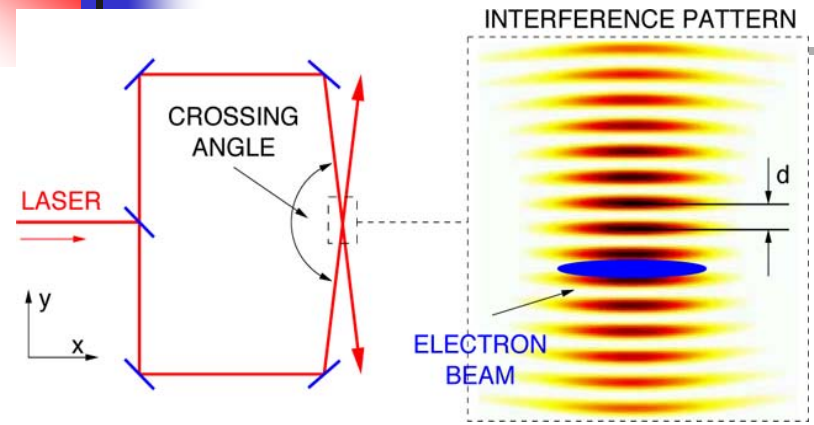


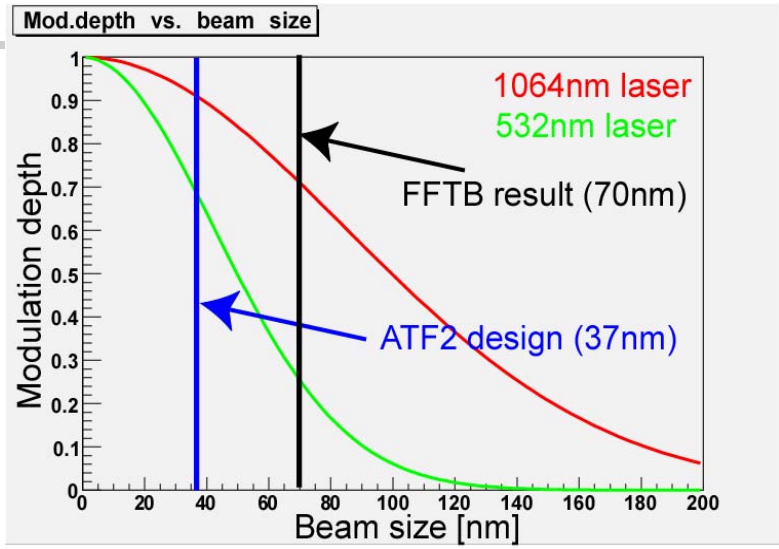
BPM electronics for cavity-BPM (SLAC)
Unit was tested in ATF.
Delivery in 2007.

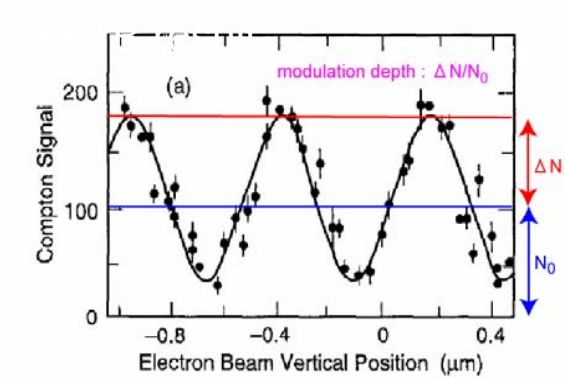
High Availability P.S.
for Q-mag, Bend and Sext (SLAC)
1 unit was tested.
Delivery in 2007.

ATF2 development Highlights

Laser Interference Monitor at ATF2 IP(Tokyo Univ.)







Shintake-monitor result in FFTB

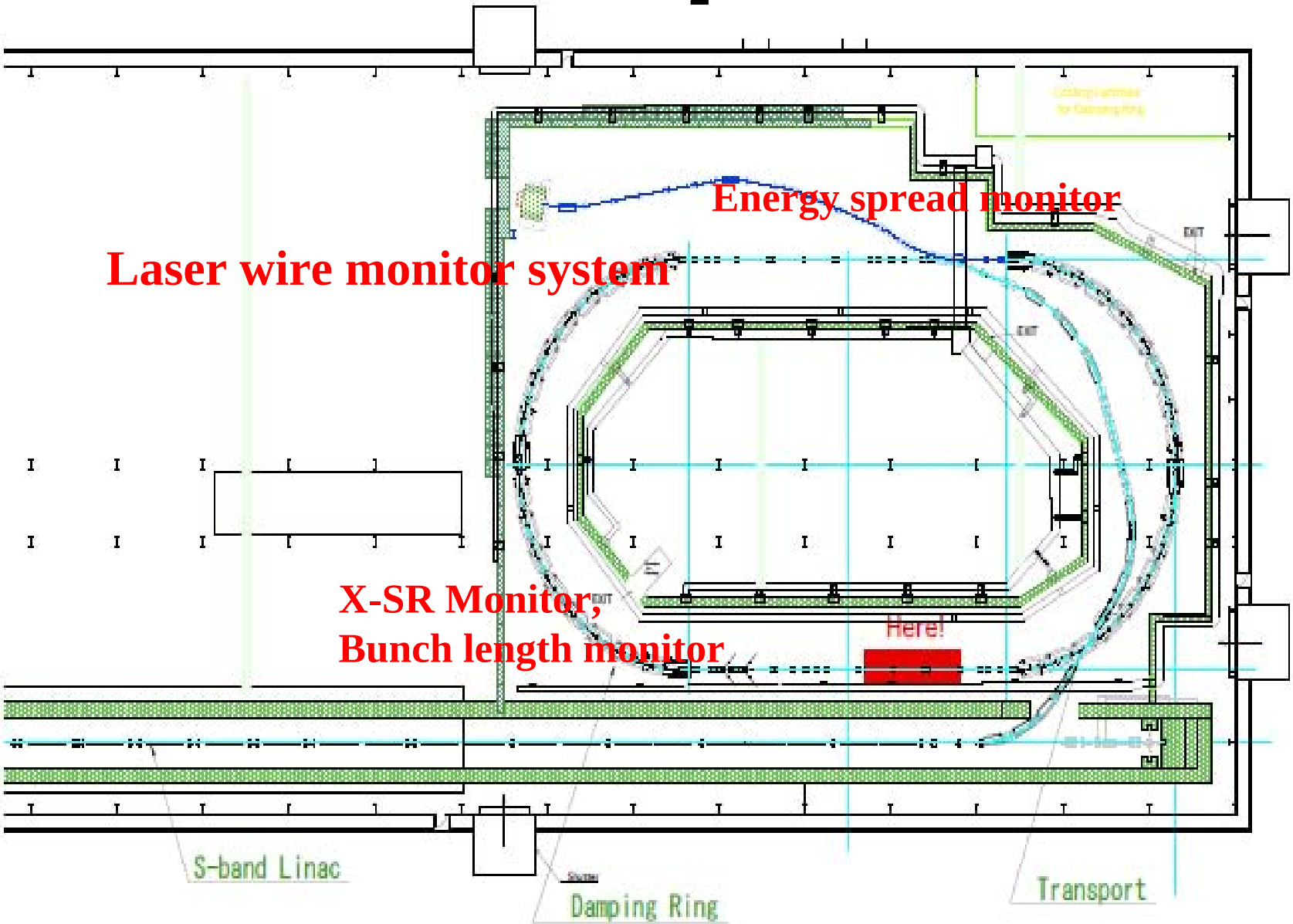
Shintake-monitor from FFTB

FFTB ~70nm -> ATF2 37nm
modification : Laser wavelength
fringe stabilization FB
new gamma detector

Posssible location for Fast Ion Study

2007/Mar/02 N.Terunuma, KEK

Gas Inlet Chamber : N_2 etc.

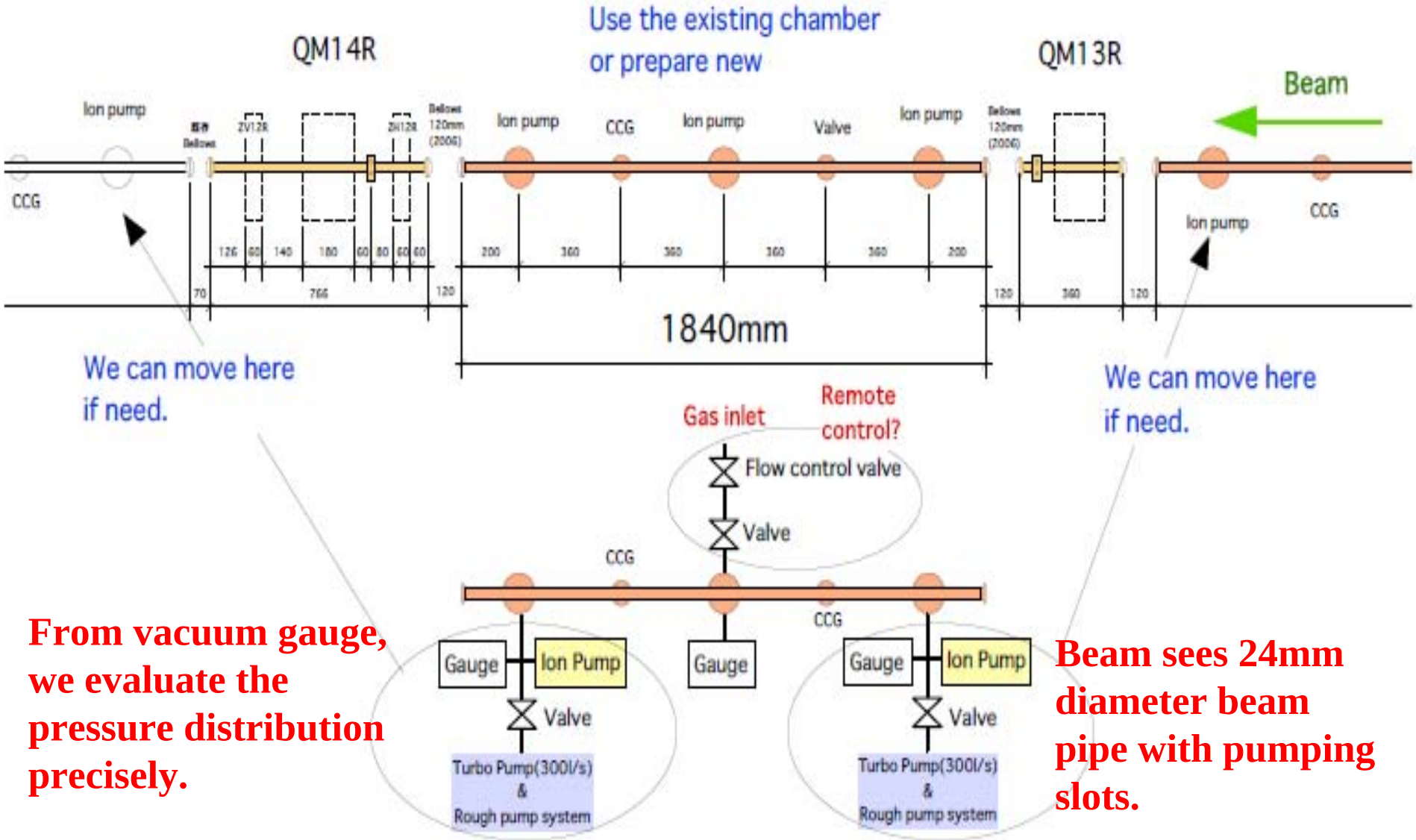


Possible location of Gas inlet chamber for fast ion study

South straight section of ATF damping ring

2007/Mar/02 N.Terunuma, KEK

To make good pressure bump



From vacuum gauge, we evaluate the pressure distribution precisely.

Beam sees 24mm diameter beam pipe with pumping slots.

Detailed Experimental plan

A. **Measurement of vacuum pressure and the main components of gas species.**

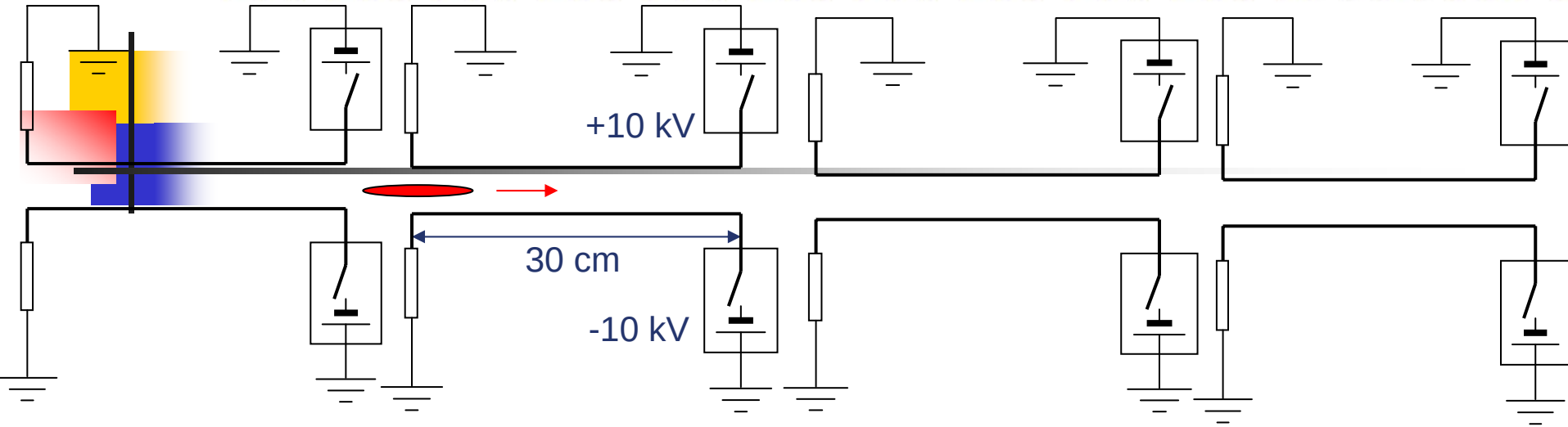
B. **Effects of pressure and bunch current:**

With different pressure conditions (2.0×10^{-5} Pa in pressure bump) by injecting nitrogen gas);
With different beam: 1 train, N of bunch =2~20, $5 \times 10^{9} \sim 2 \times 10^{10}$/bunch

C. **Gap effect**

- **repeat B with 2 and 3 bunch trains,**
- **repeat B with different length of gaps.**
- **repeat above with a different emittance (emittance ratio :changed by skew quads from 0.5% to 10%.)**

ILC DR Kicker Systems

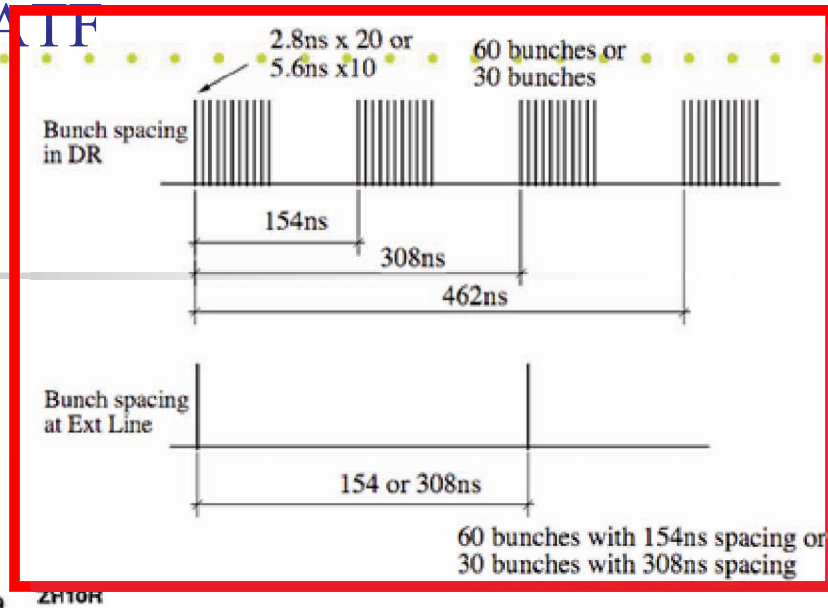


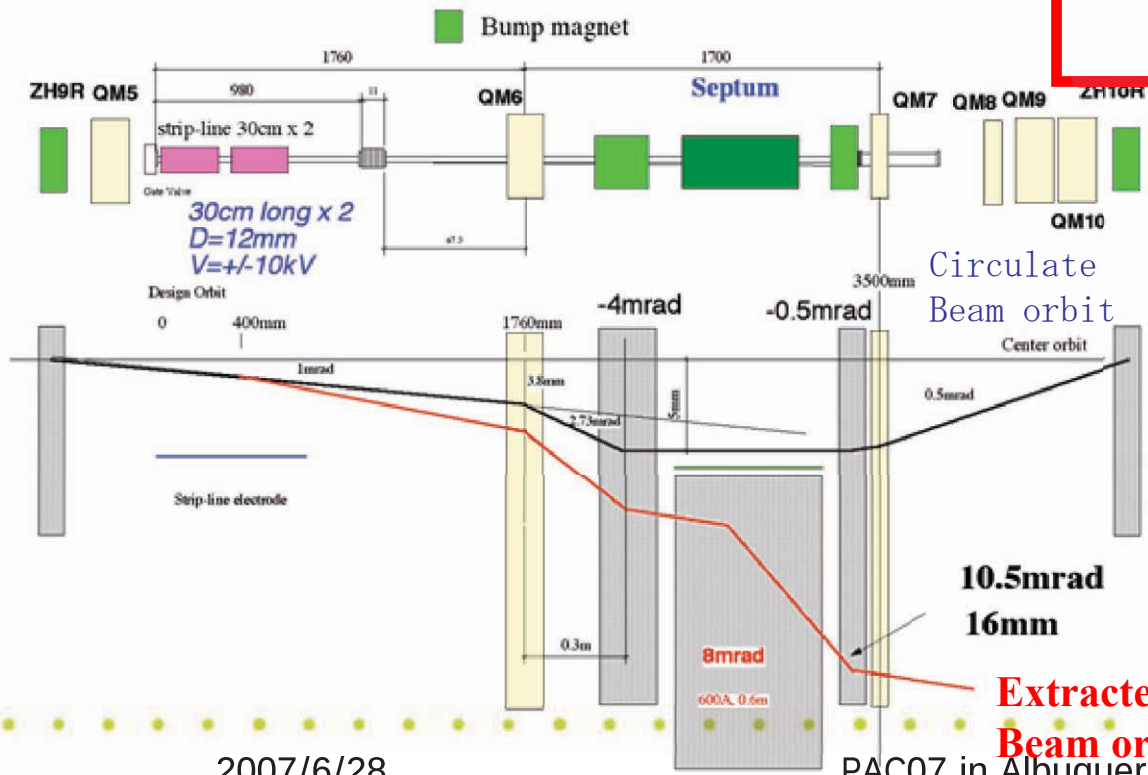
- The length of each strip-line is limited by the rise and fall time specifications: the maximum length is approximately 30 cm.
- Each strip-line is driven by two pulsers operating at ±10 kV, providing a voltage between the electrodes of 20 kV.
- A "complete" kicker is made up of 22 such units.

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.





A new design uses pulse 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 kicker.

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)

Feedforward to Extraction Line to supply stable and very flat beam : Establishment of position stability 1μm (rms) and 10prad vertical emittance at EXT until end of 2007.

Layout of KEK-ATF Extraction Line

μm Feedforward (DR BPM -> EXT Line new stripline kicker)

Cavity BPM (MM1X-MM5X)

sensor cavity

In detail see poster MOPAN109.

Prospect of ATF

- ATF International R&D will generate necessary results for ILC, especially how to control high quality beam, develop many kinds of advanced instrumentation, educate young accelerator physicists and engineers.
- ILC like beam which means 60 bunches with bunch spacing 154nsec, in the future.
- Realization of 37nm beam for long period.

From US, EU, Russia, China, Korea, India and Japanese Univ., Many young physicists and engineers are learning and developing advanced accelerator technologies for ILC.

ATF Control Room 2005.3.9