ATF/ATF2 research program and present orientations at KEK for ILC

Ongoing unique test facility for ILC with a low emittance beam

1. Outline of ATF
2. Achievement of ATF so far
3. Future plan
4. Present orientations
5. Prospect of ATF

Junji Urakawa (KEK) for

the ATF International Collaboration

ATF
Accelerator Test Facility

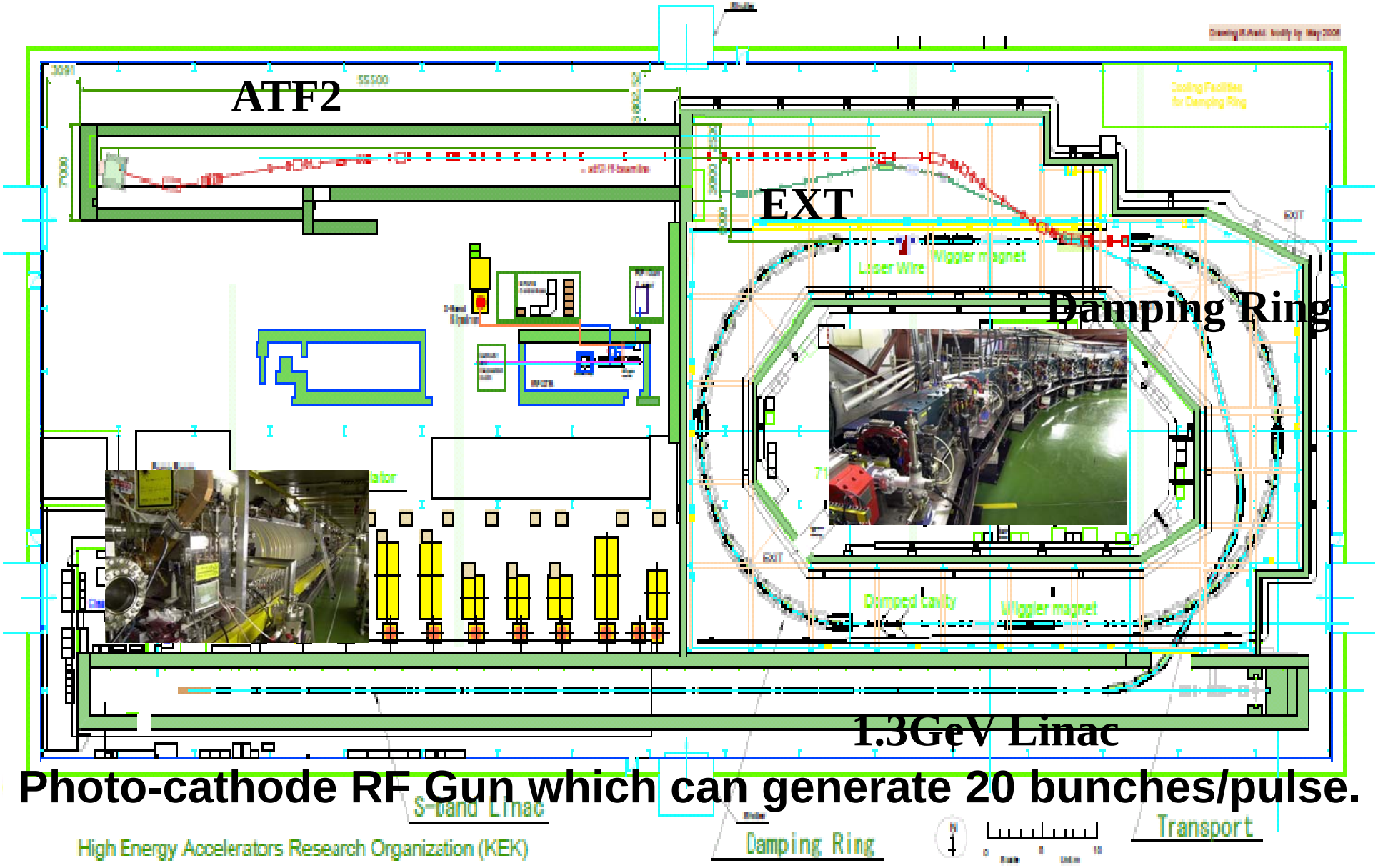


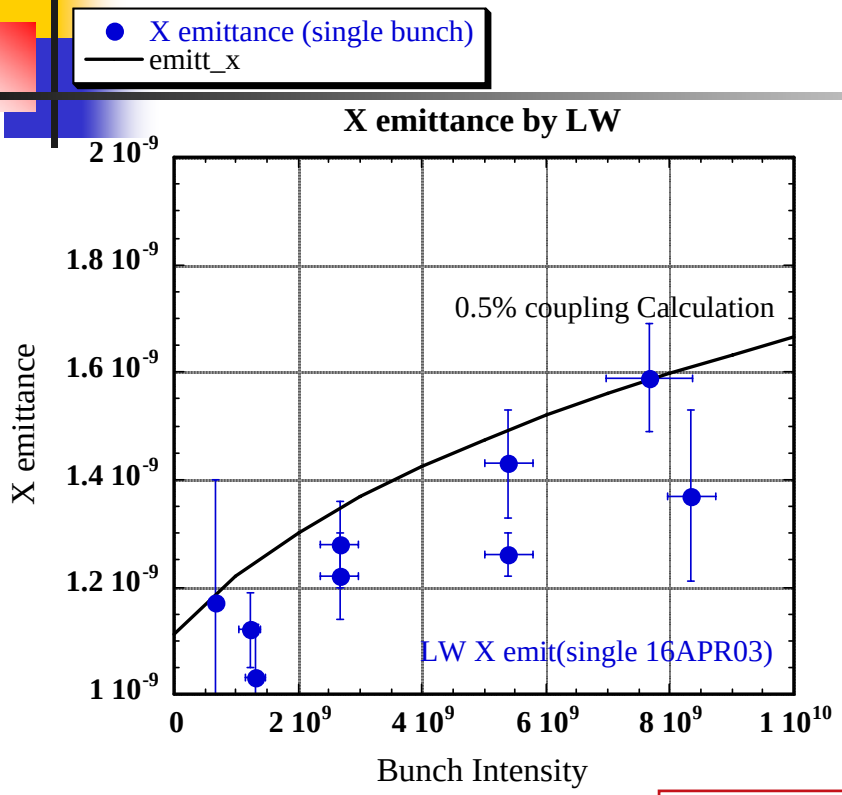
Photo-cathode RF Gun which can generate 20 bunches/pulse.

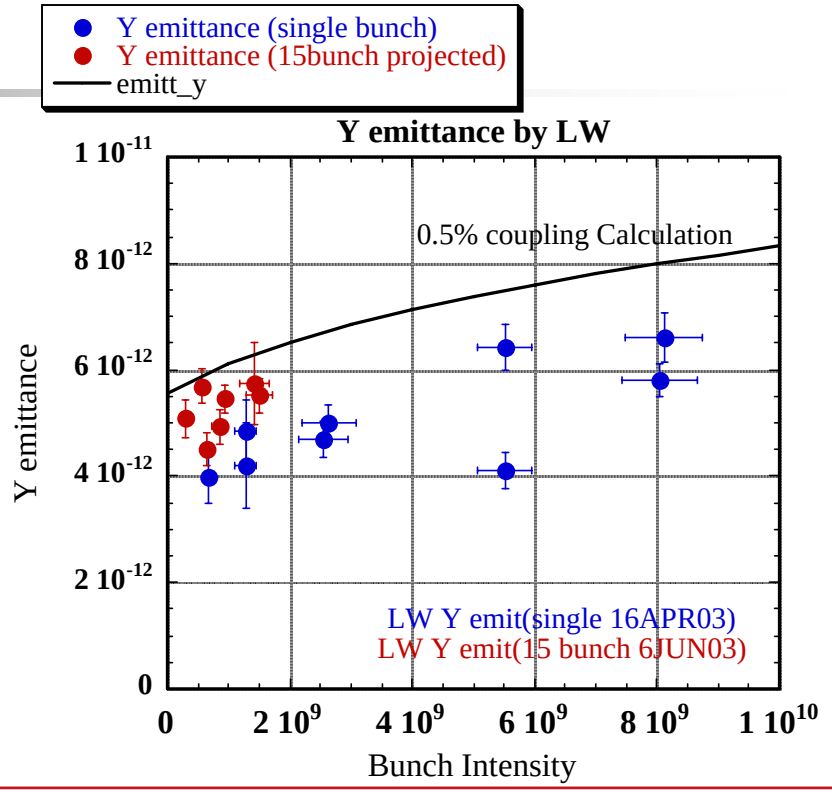
Achievement of ATF

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.**

Emittance measured by CW Laser wire in 2003





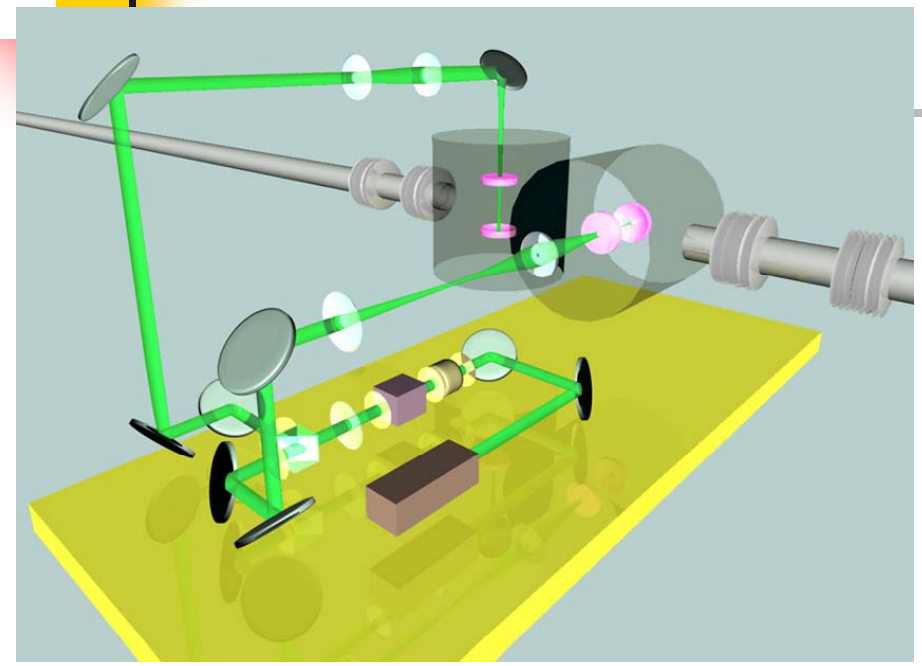
< 0.5% y/x emittance ratio
Y emittance =4pm at small intensity

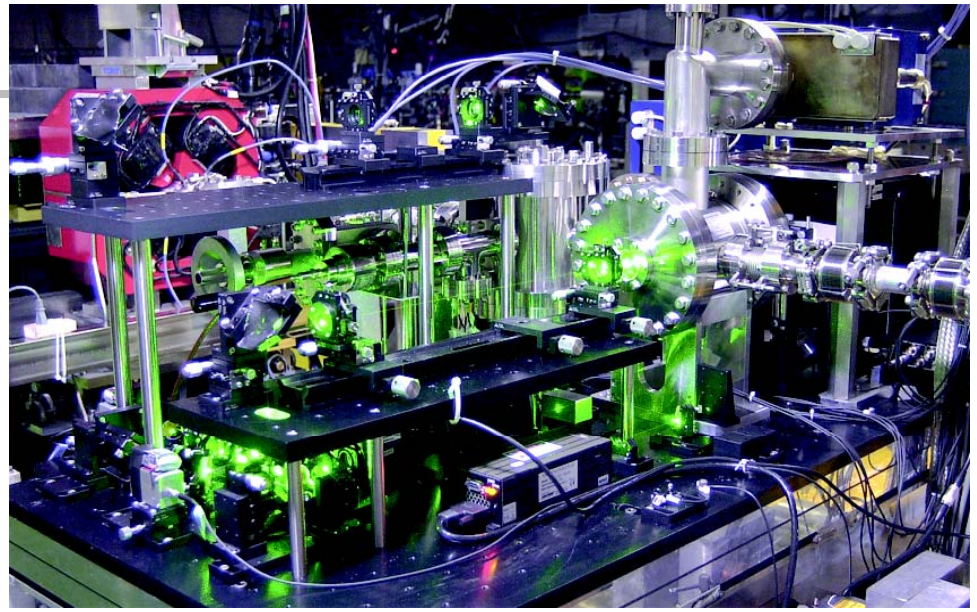
VOLUME 92, NUMBER 5 PHYSICAL REVIEW LETTERS week ending 6 FEBRUARY 2004

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

Y. Honda,[1] K. Kubo,[2] S. Anderson,[3] S. Araki,[2] K. Bane,[3] A. Brachmann,[3] J. Frisch,[3] M. Fukuda,[6] K. Hasegawa,[14] H. Hayano,[2] L. Hendrickson,[3] Y. Higashi,[2] T. Higo,[2] K. Hirano,[13] T. Hirose,[15] K. Iida,[12] T. Imai,[9] Y. Inoue,[7] P. Karataev,[6] M. Kuriki,[2] R. Kuroda,[8] S. Kuroda,[2] X. Luo,[11] D. McCormick,[3] M. Matsuda,[10] T. Muto,[2] K. Nakajima,[2] Takashi Naito,[2] J. Nelson,[3] M. Nomura,[13] A. Ohashi,[6] T. Omori,[2] T. Okugi,[2] M. Ross,[3] H. Sakai,[12] I. Sakai,[13] N. Sasao,[1] S. Smith,[3] Toshikazu Suzuki,[2] M. Takano,[13] T. Taniguchi,[2] N. Terunuma,[2] J. Turner,[3] N. Toge,[2] J. Urakawa,[2] V. Vogel,[2] M. Woodley,[3] A. Wolski,[4] I. Yamazaki,[8] Yoshio Yamazaki,[2] G. Yocky,[3] A. Young,[3] and F. Zimmermann[5]

Laser wire beam size monitor in DR



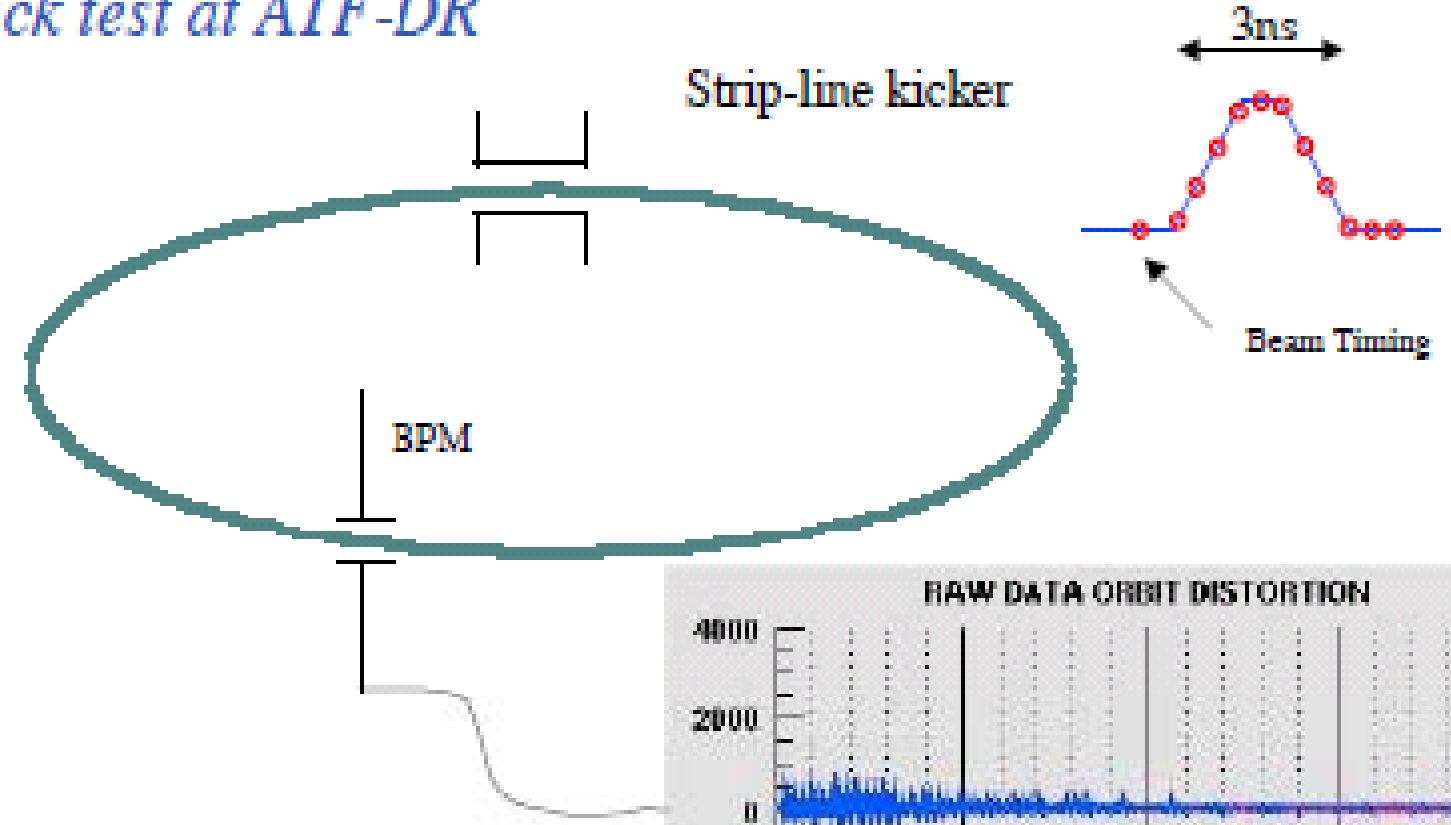


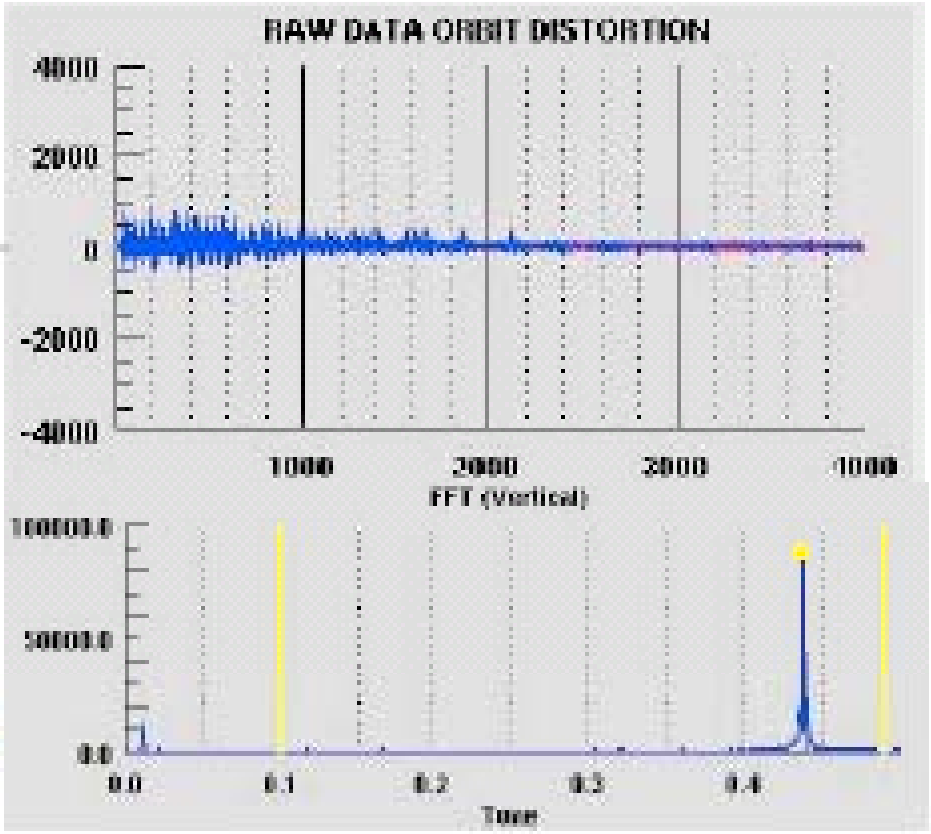
300mW 532nm Solid-state Laser fed into optical cavity

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

In 2006



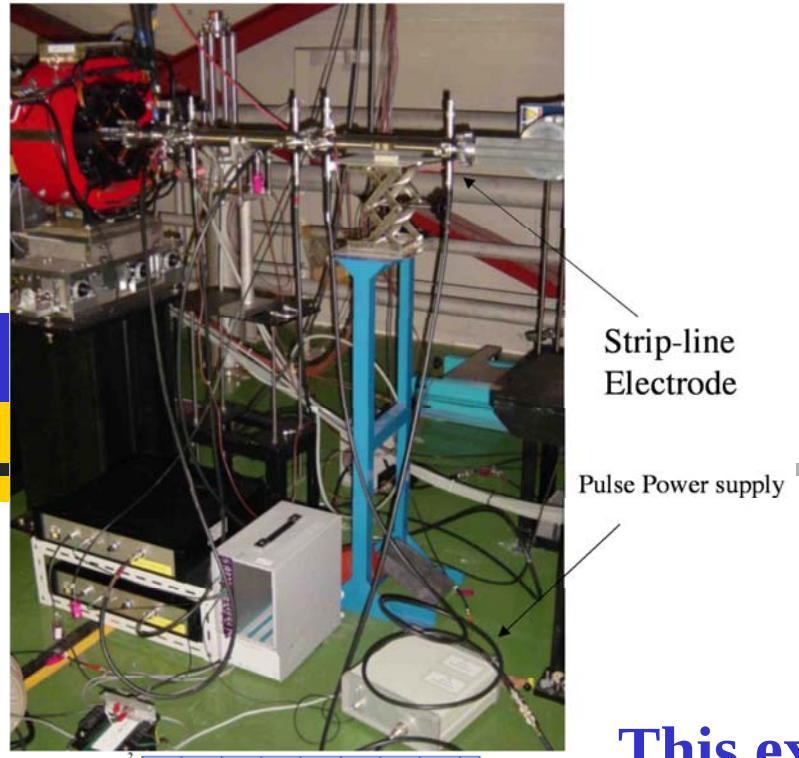


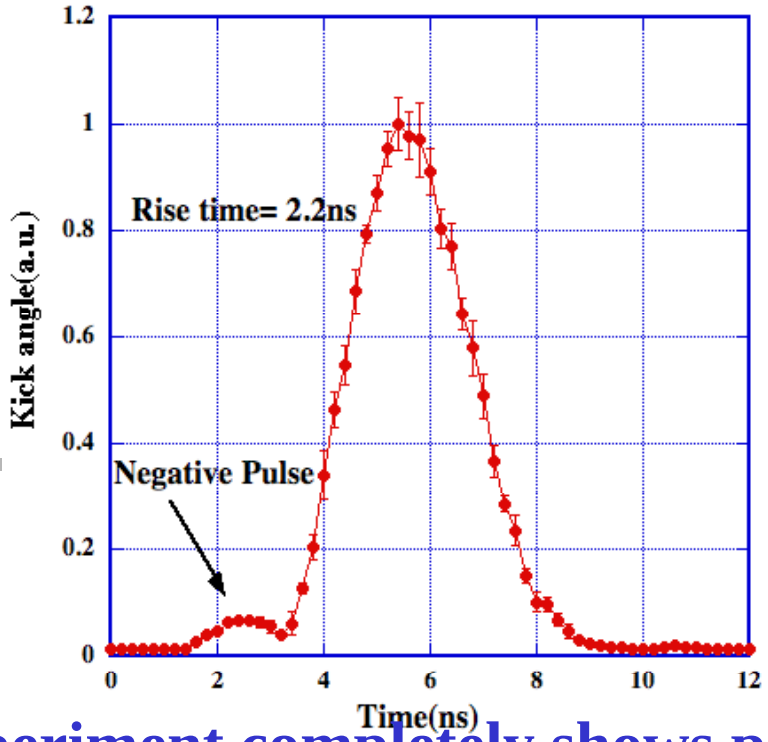
The kicker pulse is applied to the strip-line electrode at just the time of the beam goes through the electrode.

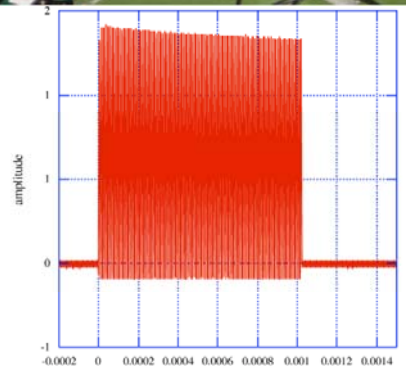
The beam kick is observed by a turn-by-turn BPM as the amplitude of the oscillation of the betatron frequency component.

The kick effect is measured by scanning the pulse timing.

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







Pulse Train (3000 pulse)Output from FID Pulser

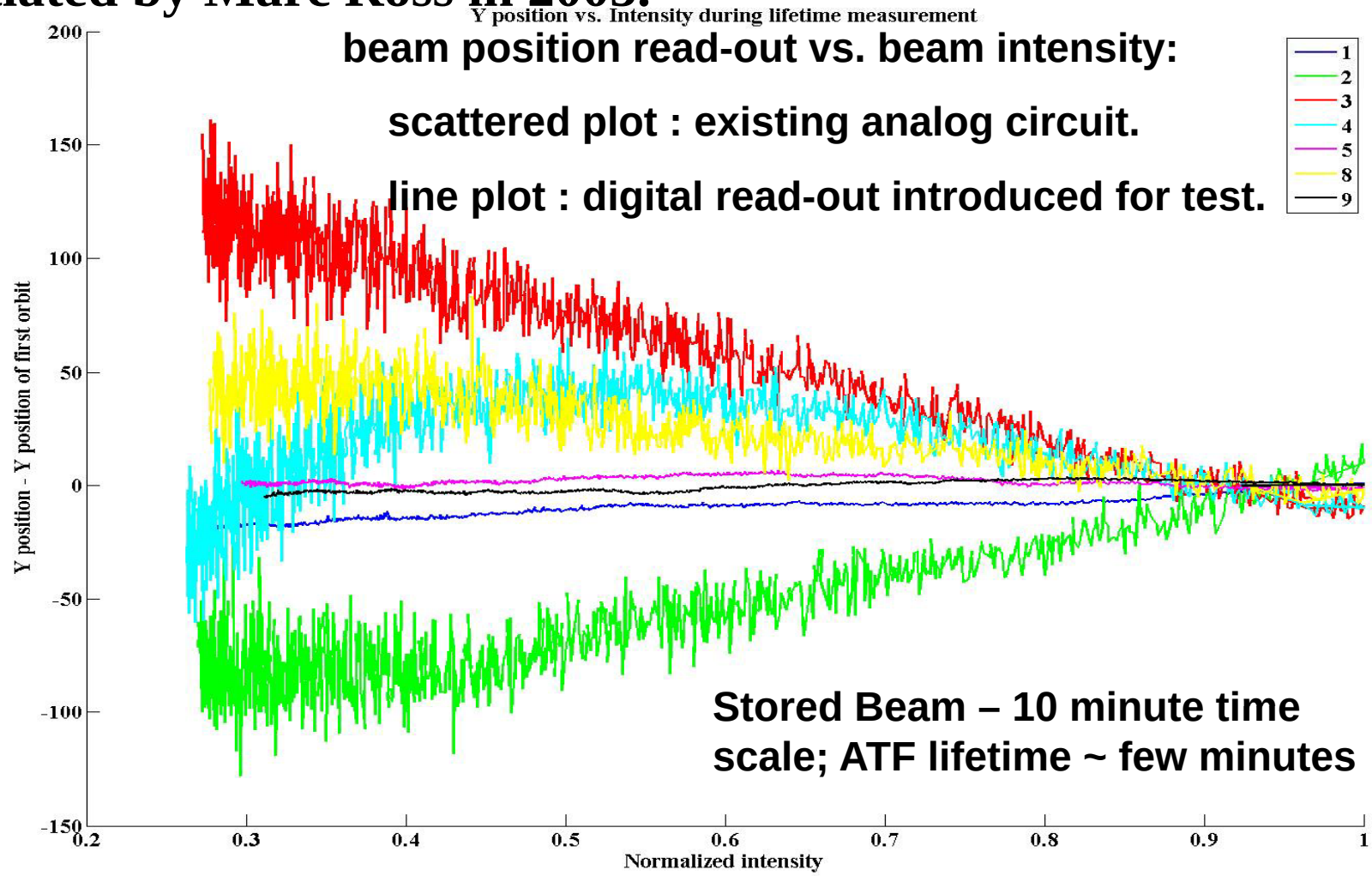
This experiment completely shows perfect kick timing control.

rise time improvement
by using waveform compensator.

3 ns -> 2.2 ns

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

Initiated by Marc Ross in 2005.



beam position read-out vs. beam intensity:

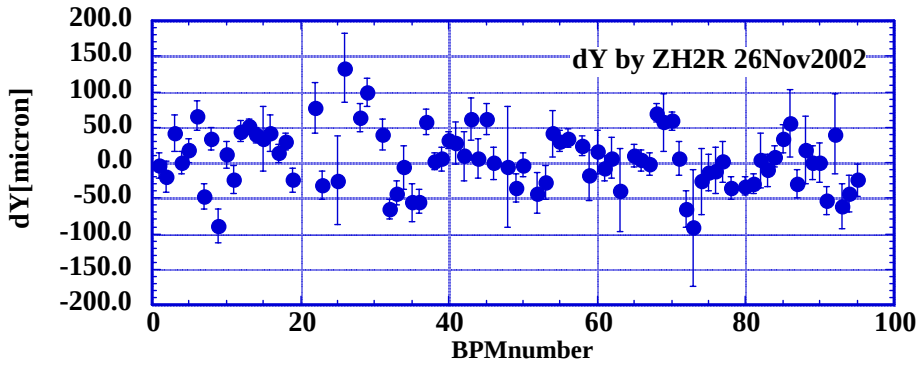
scattered plot : existing analog circuit.

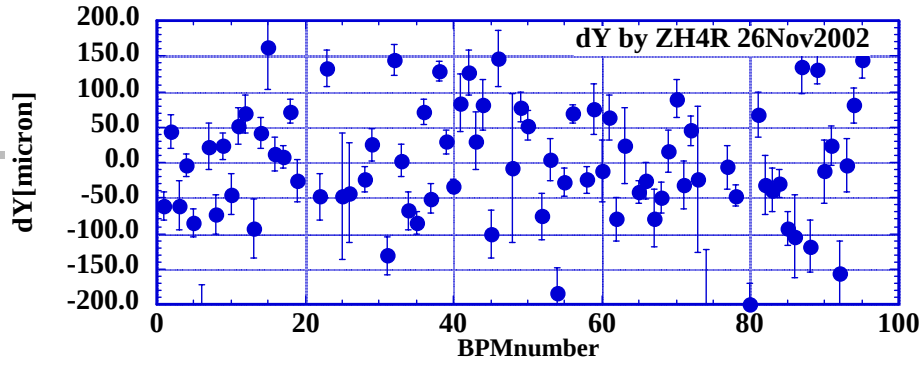
line plot : digital read-out introduced for test.

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

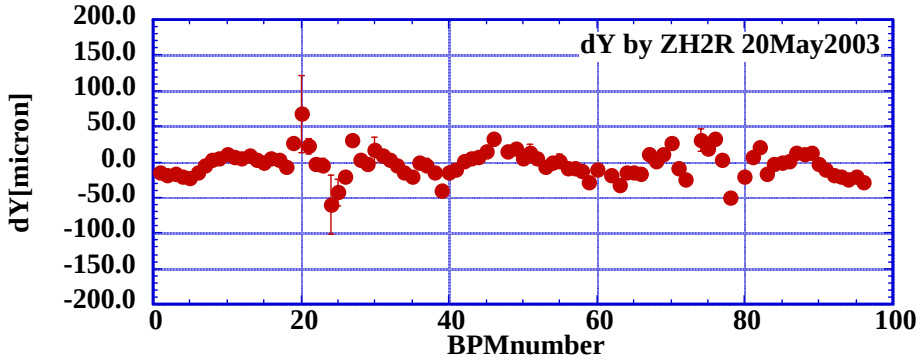
X to Y coupling Improvement

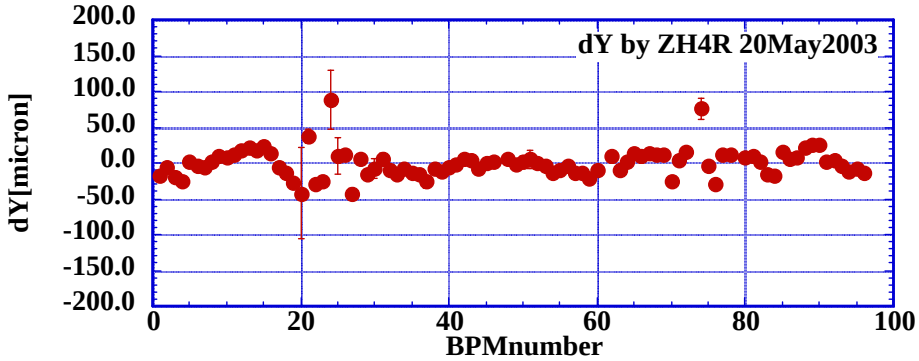
20μm BPM Resolution with old circuit (1997-2002)





3μm BPM Resolution with present circuit (2003-2007)



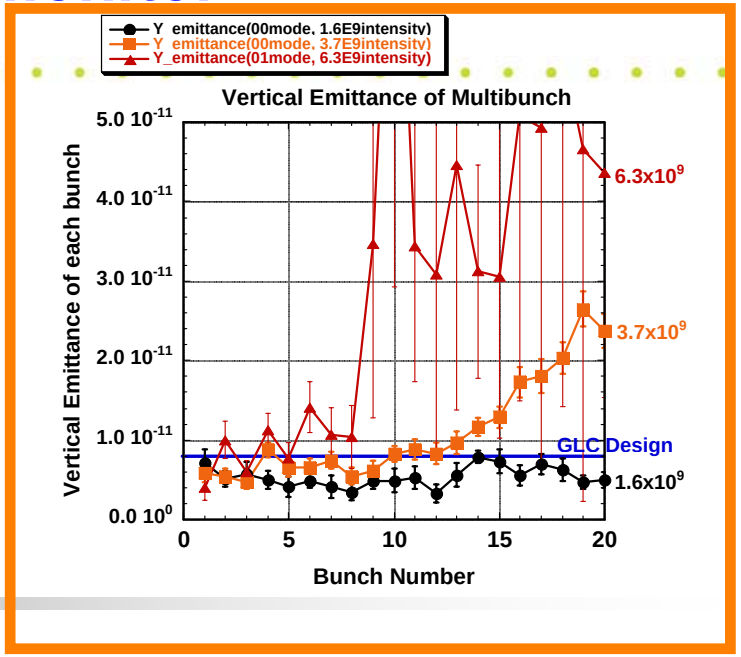


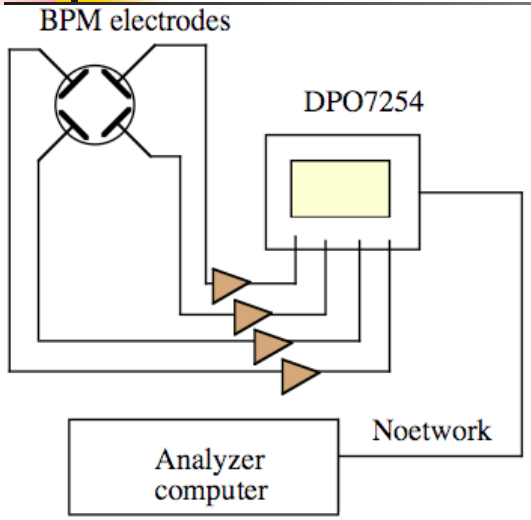
Upgrade of BPM Resolution (~ 0.1μm) with new circuit by SLAC and FNAL. Surely, we will achieve 2pm-rad. Possibly 1pm.

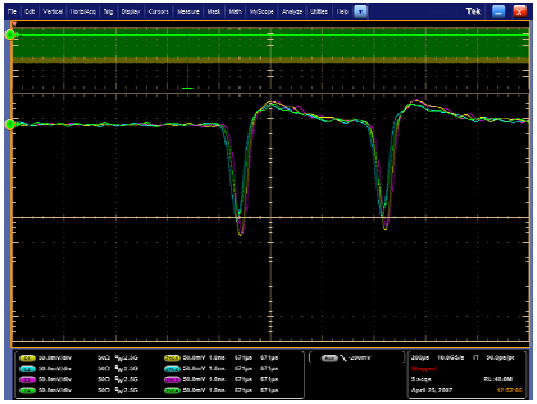
Multi-bunch Turn-by-turn monitor

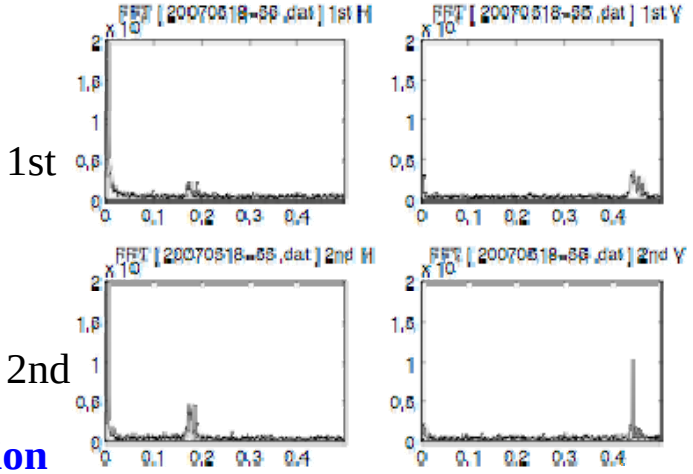
By T. Naito (KEK) in 2007

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.





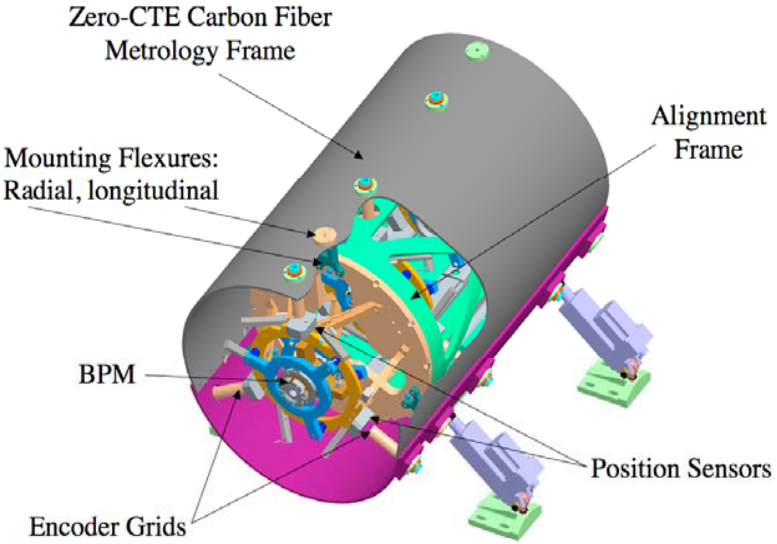


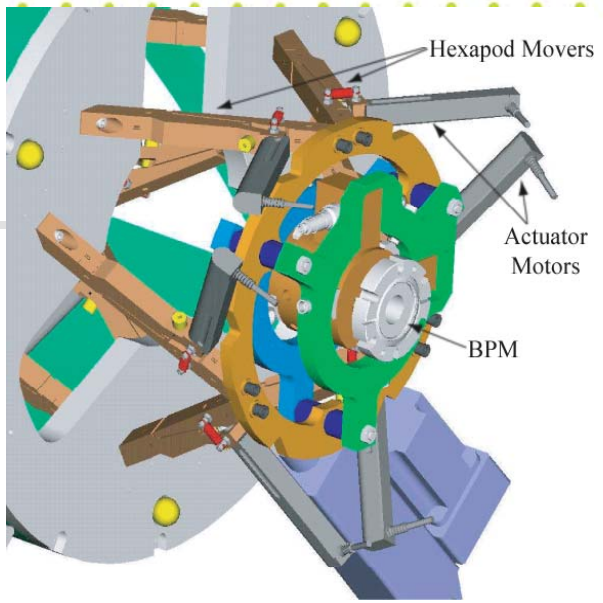


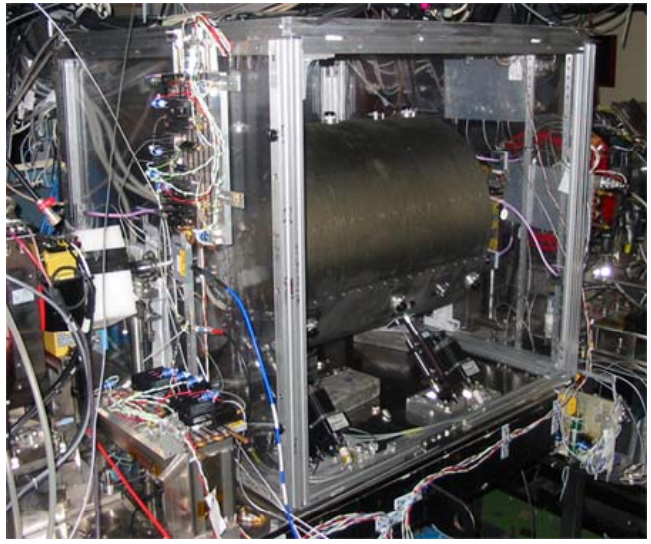
The preliminary results shows the different oscillation amplitude of the tune-X and the tune-Y for the 1st and 2nd bunches at just after injection.

nm resolution BPM

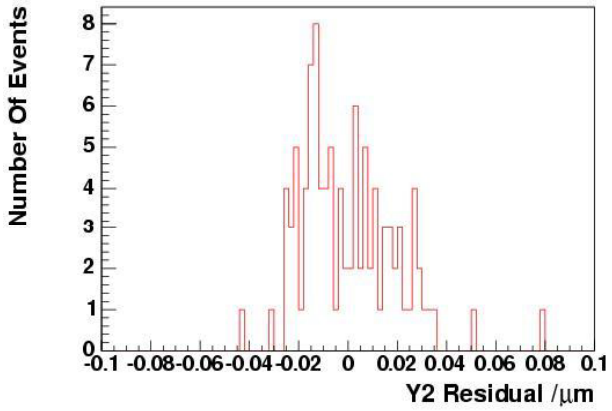
(SLAC, LLNL, UK-University, KEK)







ATF single bunch beam test

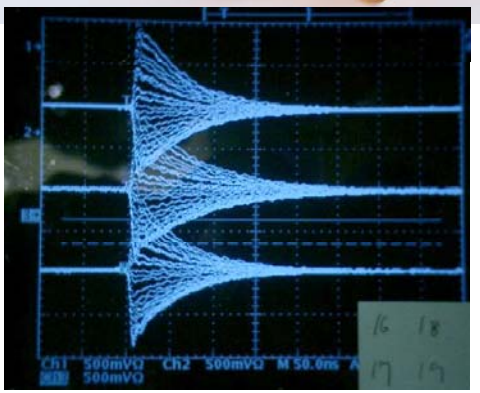


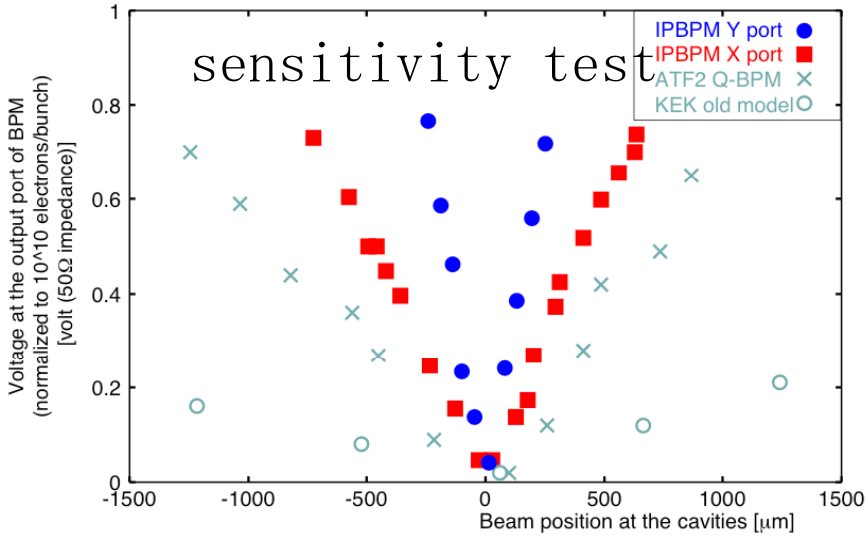
16nm resolution achieved

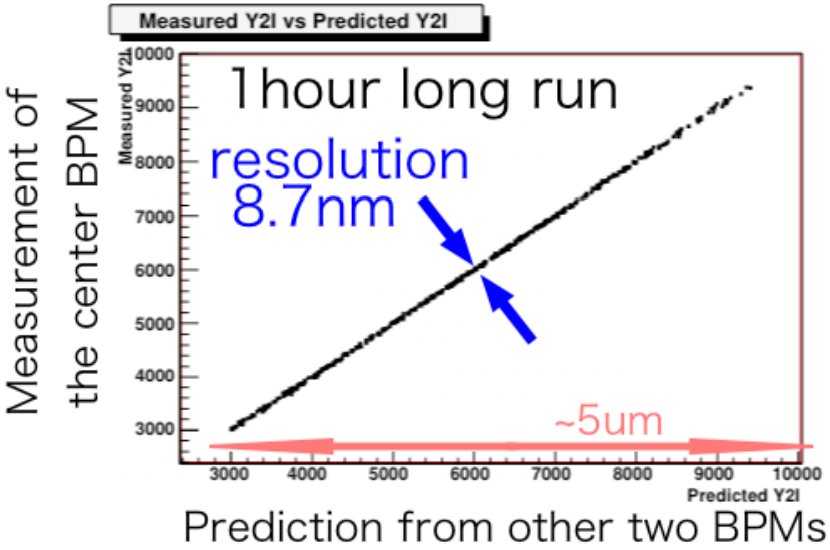
ATF2 IP-BPM

By Yosuke Honda (KEK) in 2007

- 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 measurement

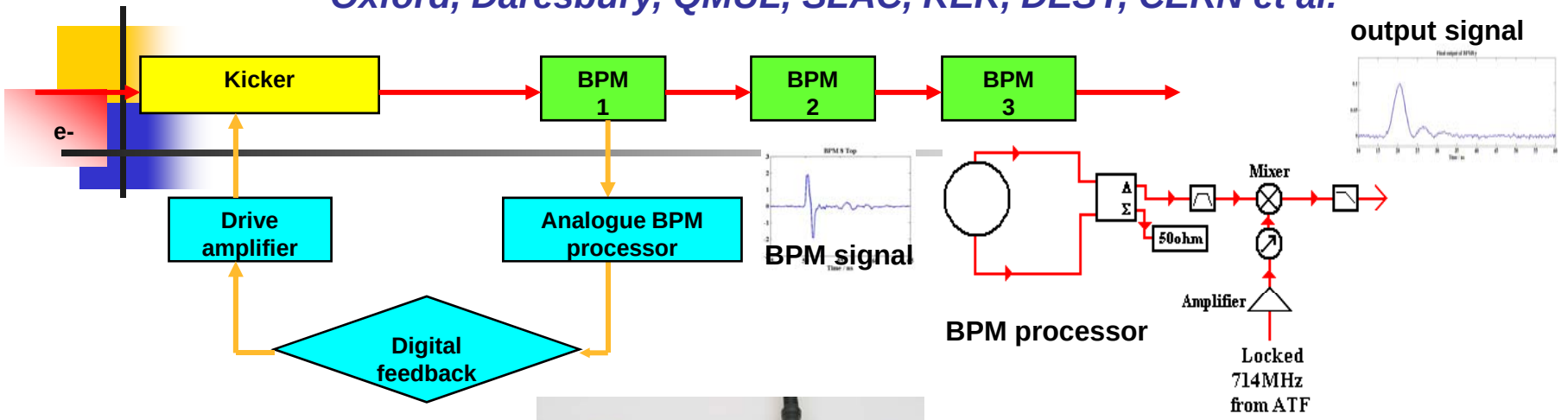






FONT4 : Digital IP feedback R&D at ATF

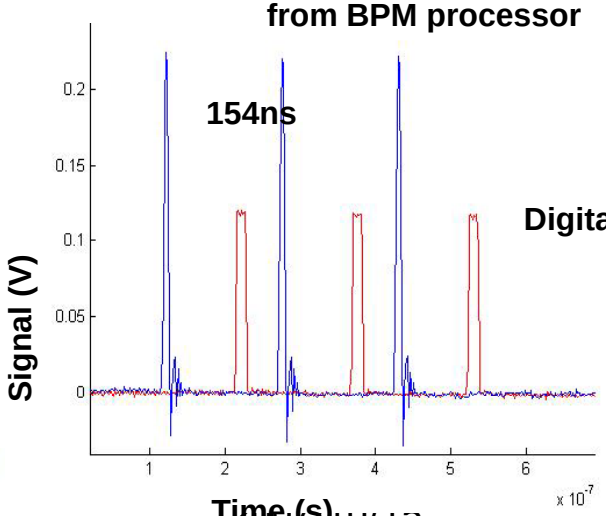
Oxford, Daresbury, QMUL, SLAC, KEK, DESY, CERN et al.



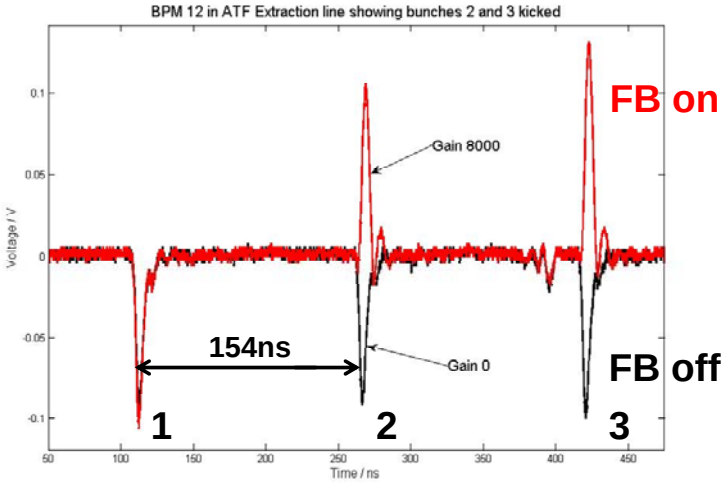
signal pass latency : 25ns
BPM processor:7ns
Digital board:68ns
drive amplifier:40ns ***total:140ns***

Digital Board development

Analogue input from BPM processor

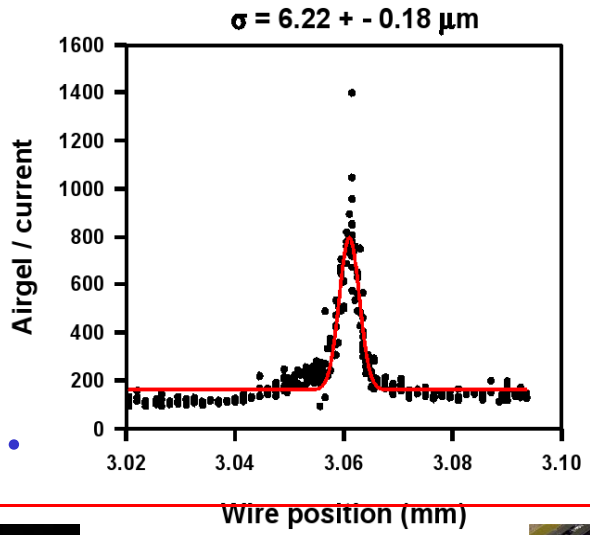


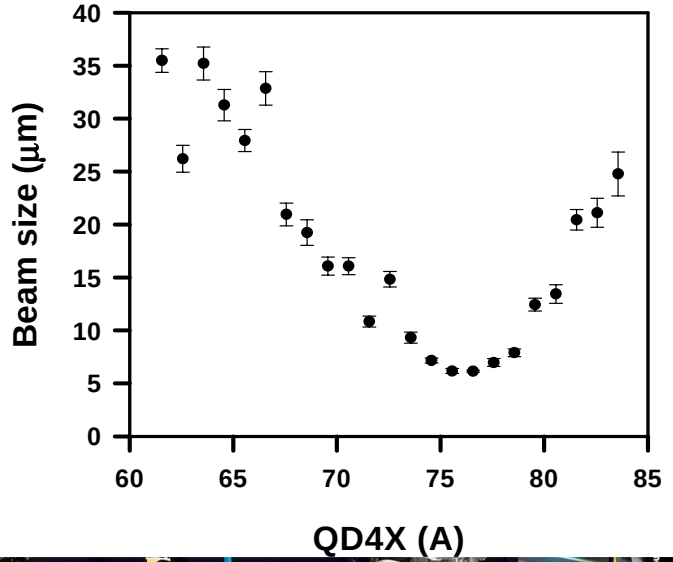
Digital processor output



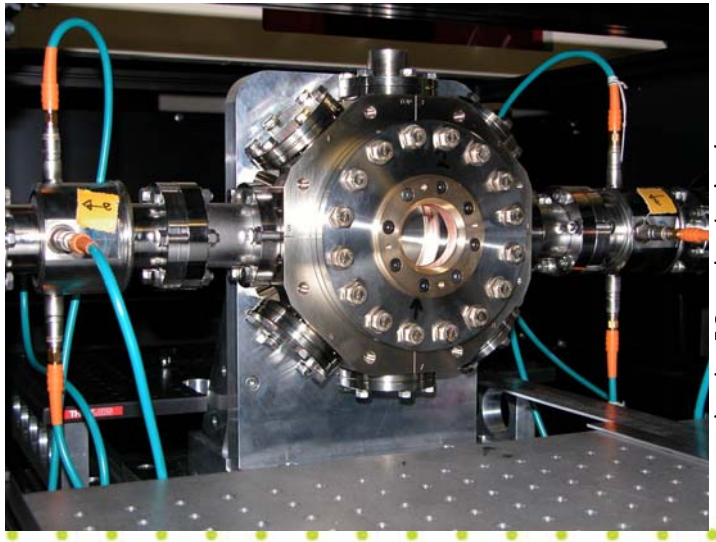
Laser-wire at ATF-EXT

6min 43s

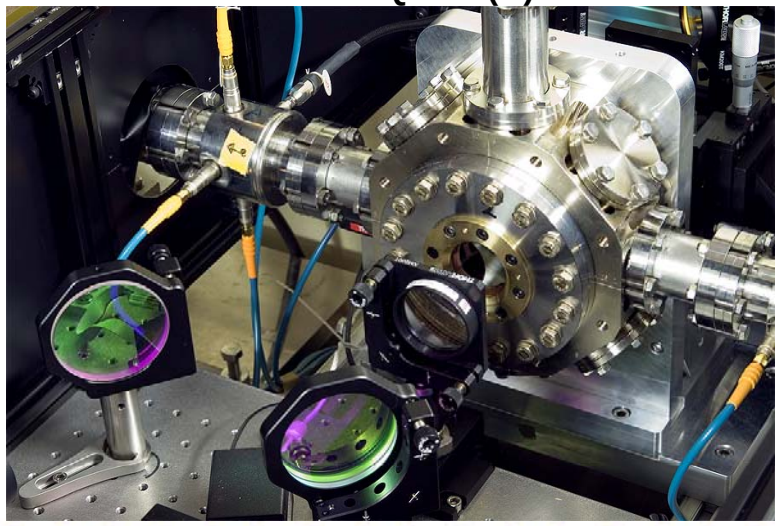




JAI, RHUL and KEK led by Grahame Blair .



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



Future plans

- ATF2 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

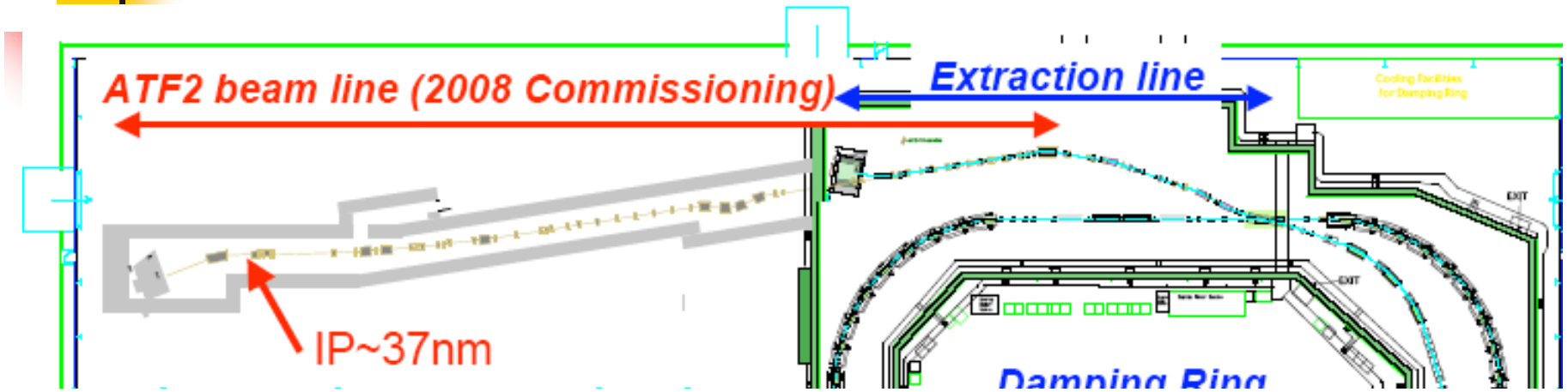
ATF2 Status for BDS R&D

ATF2 Project (34nm Final Focus beam line)

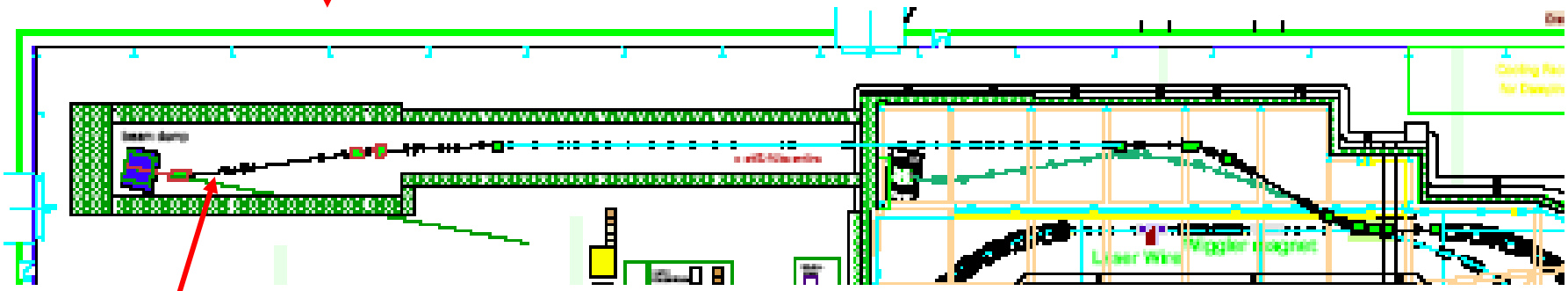
Status

- **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

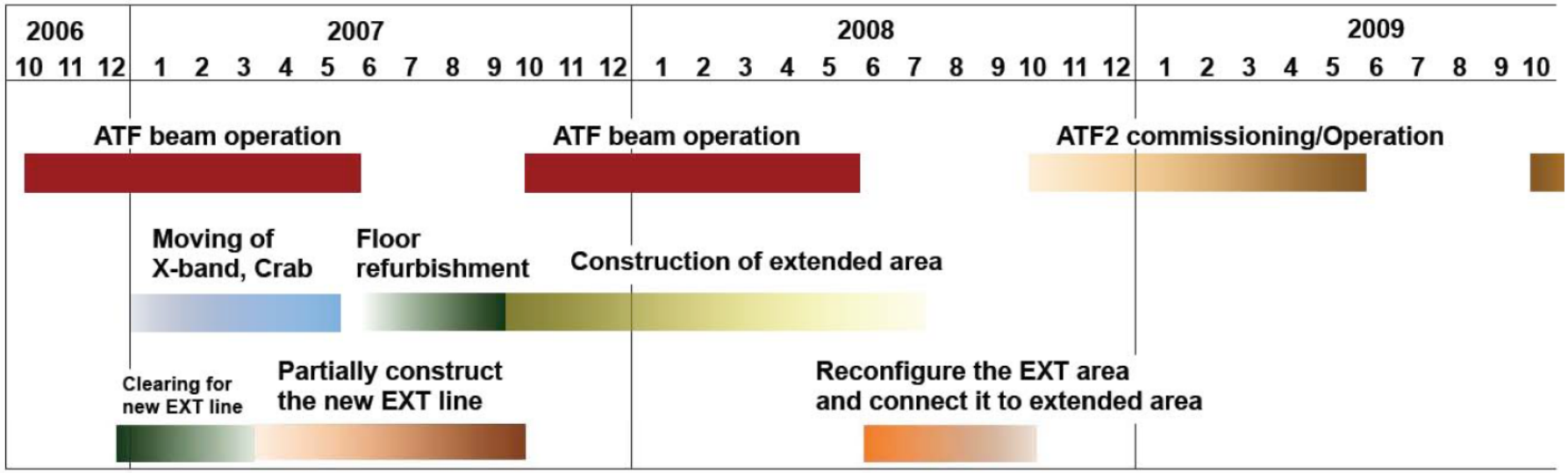


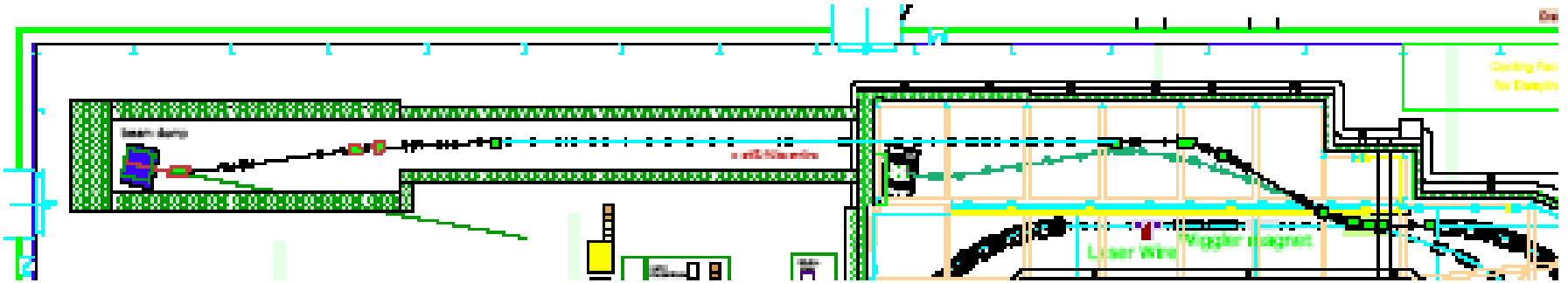
Optics & Lattice Design was fixed in June 2006.



IP ~34nm vertical size

ATF2 construction schedule

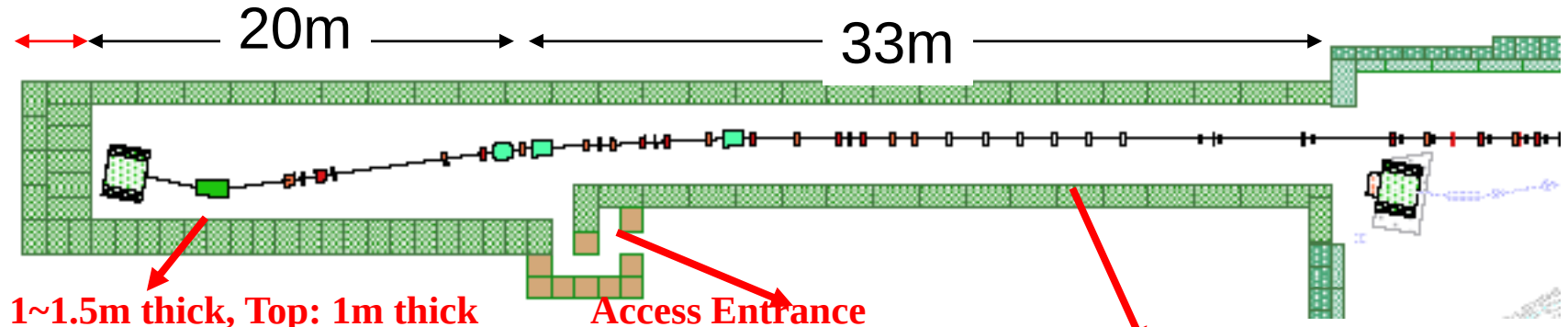




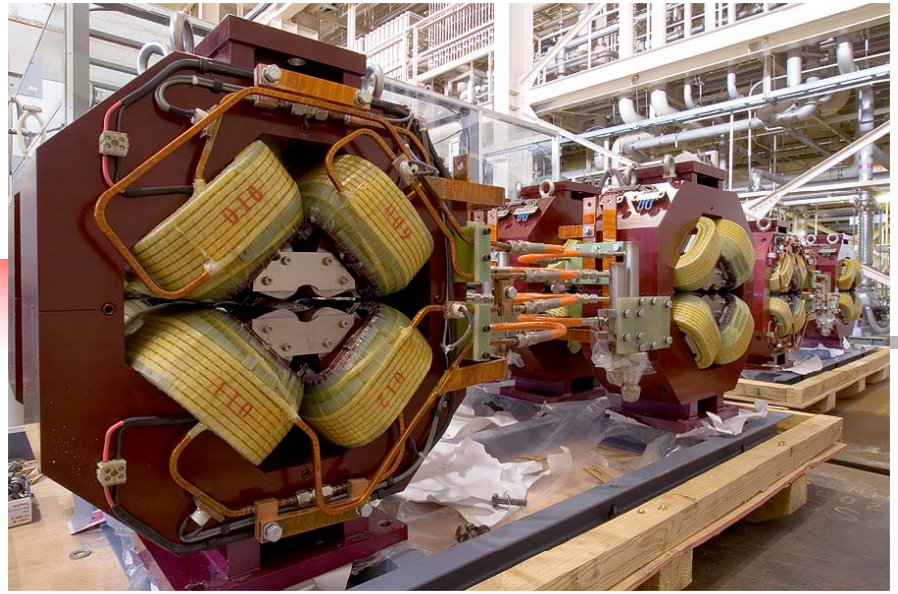
- **ATF2 beam will come in October, 2008.**

Area for ATF2, 15/Oct./2007

Floor refurbishment was finished at the end of Sep.



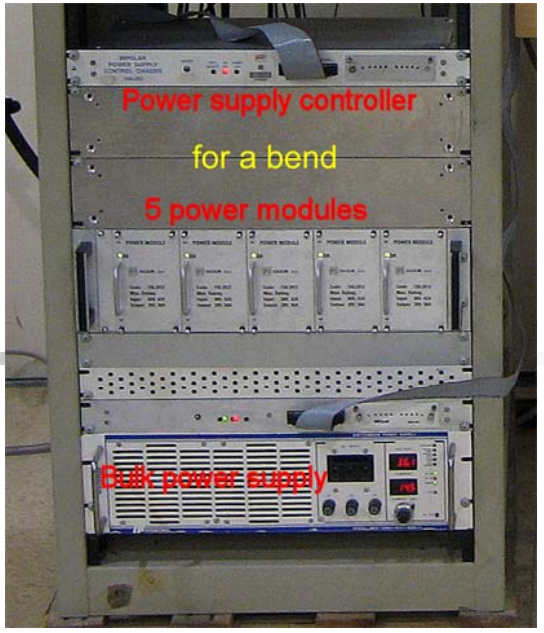
ATF2 development Highlights



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

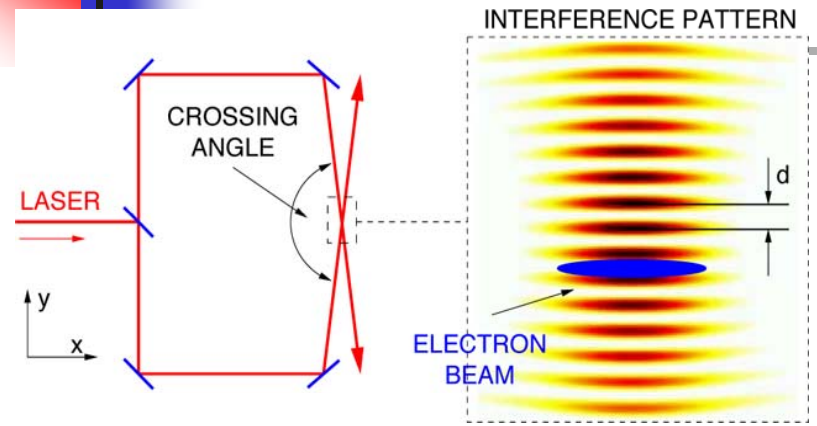


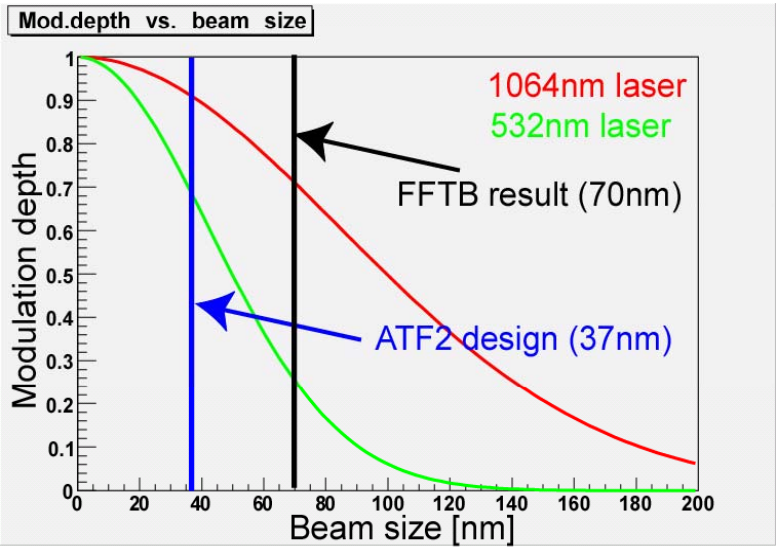
BPM electronics for cavity-BPM (SLAC)
Unit was tested in ATF.
Delivery in 2007.

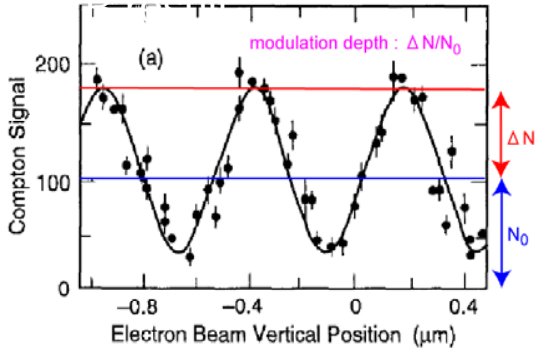
High Availability P.S.
for Q-mag, Bend and Sext (SLAC)
1 unit was tested.
Delivery in 2007.

ATF2 development Highlights

Laser Interference Monitor at ATF2 IP(Tokyo Univ.)







Shintake-monitor result in FFTB

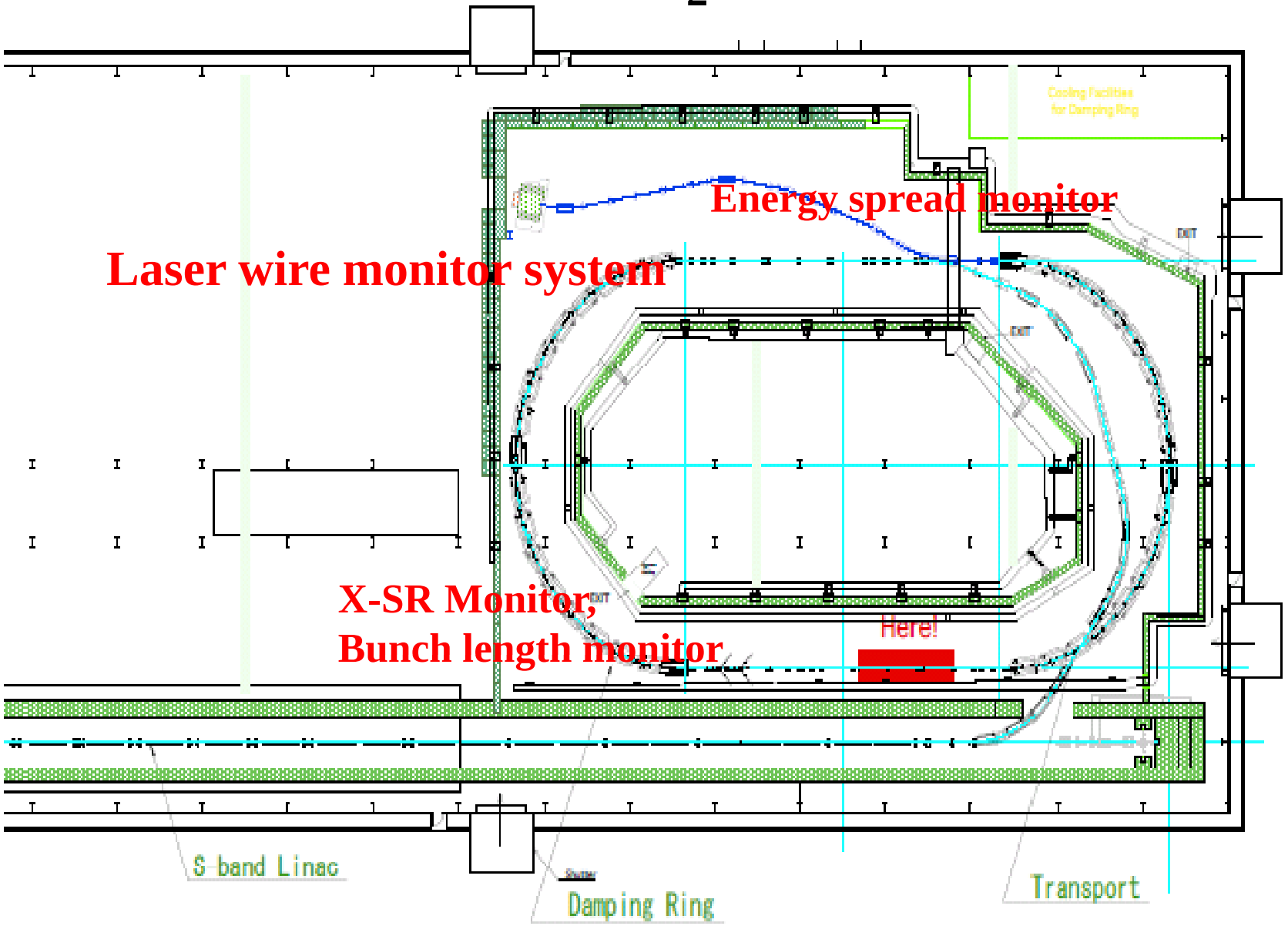
Shintake-monitor from FFTB

FFTB ~70nm -> ATF2 34nm
modification : Laser wavelength
fringe stabilization FB
new gamma detector

Posssible location for Fast Ion Study

Gas Inlet Chamber : N_2 etc.

2007/Mar/02 N.Terunuma, KEK

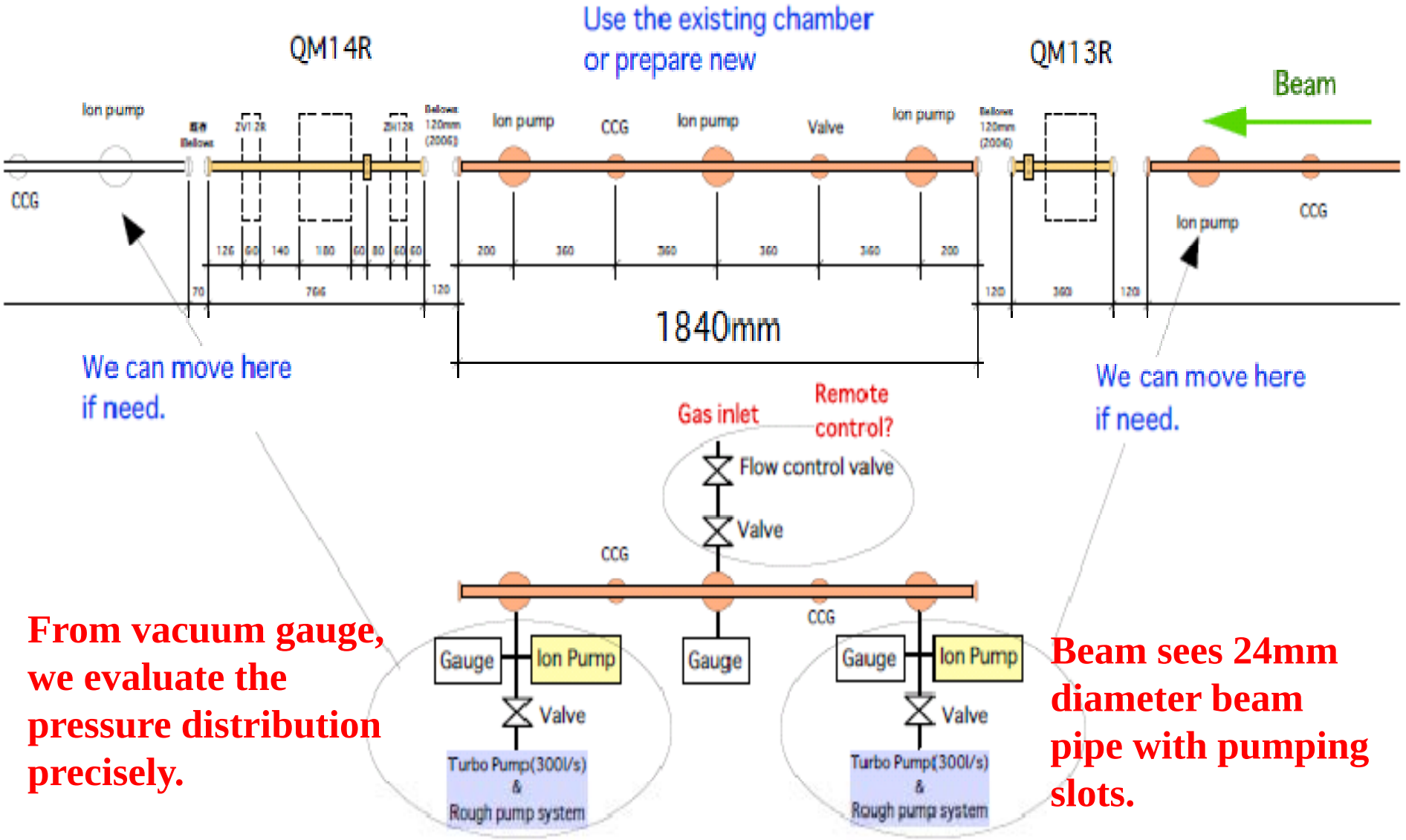


Possible location of Gas inlet chamber for fast ion study

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, 5×10^{9}~2×10^{10}/bunch

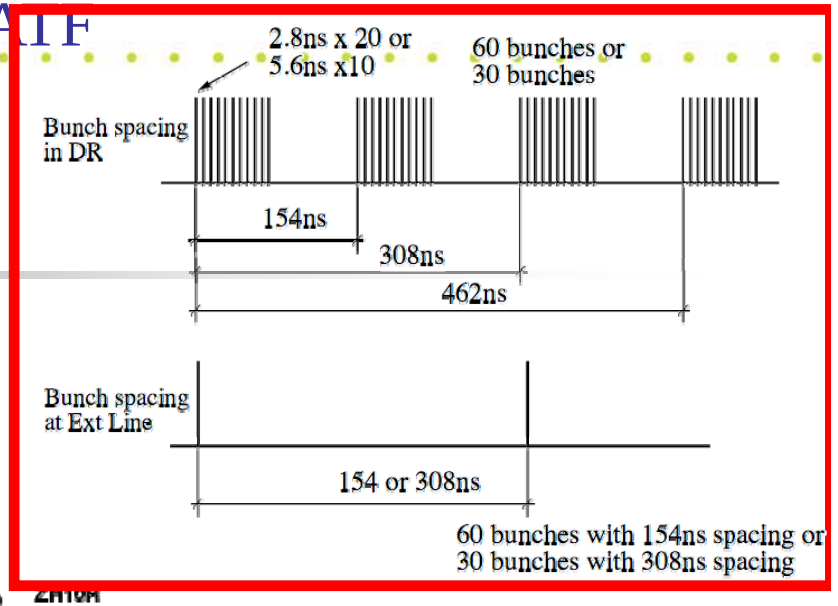
C. **Gap effect**

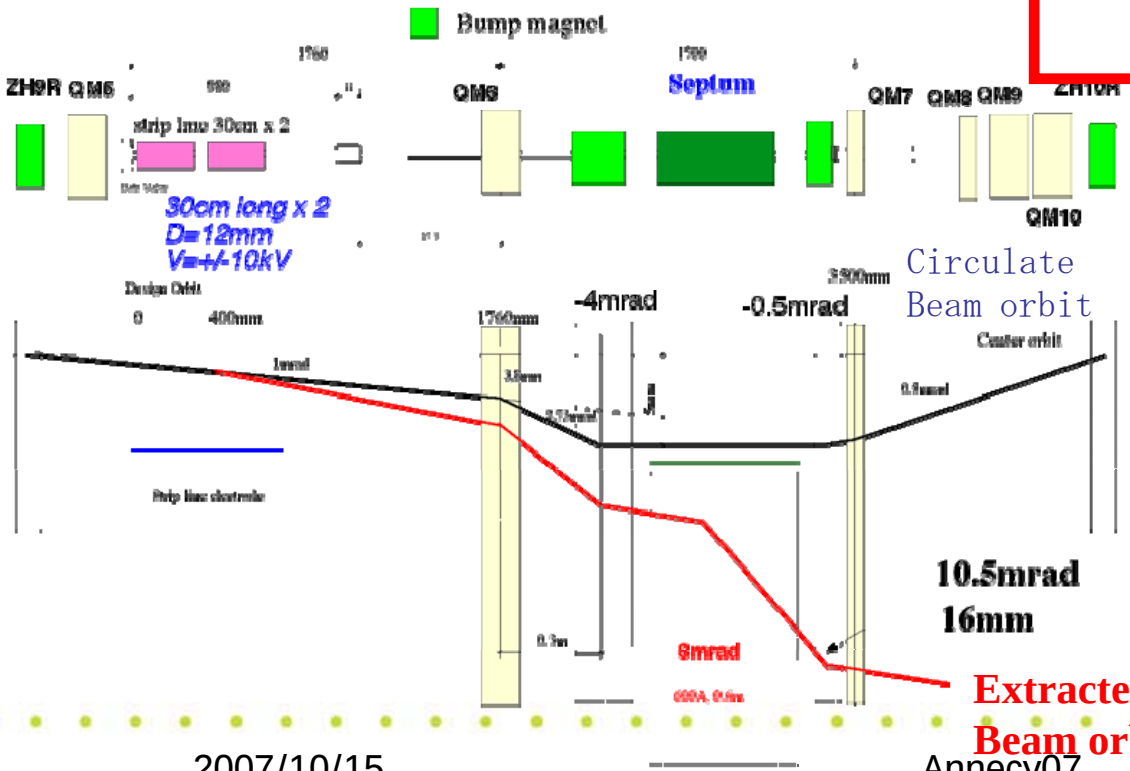
- **repeat B with 2 and 3 bunch trains,**
- **repeat B with different length of gaps.**
- **repeat above with a different emittance (emittance ratio :changed by skew quads from 0.5% to 10%.)**

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.





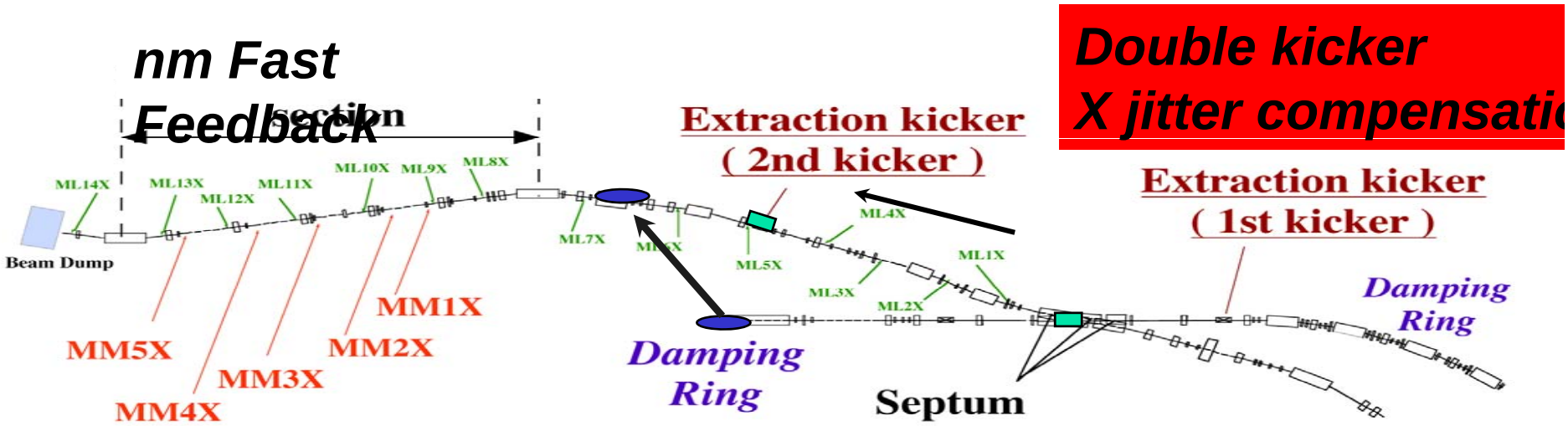
A new design uses pulse bump magnets and a thin septum magnet to help making the extraction orbit. This design makes a bump orbit after beam damping, then each beam is extracted bunch-by-bunch by the strip-line kicker.

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

Present orientations

- Increase bunch charge to 2×10^{10}.
- Maintain vertical emittance 4pm or achieve smaller one.
- Find and reduce coupling source around extraction area.
- Reduce orbit jitter.
- Establish quick and precise beam profile diagnostic.
- Increase number of bunch/train for multi-bunch/train operation at ATF2.

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 30 bunches with bunch spacing 308nsec, in the future.
  - Realization of 34nm beam for long period.