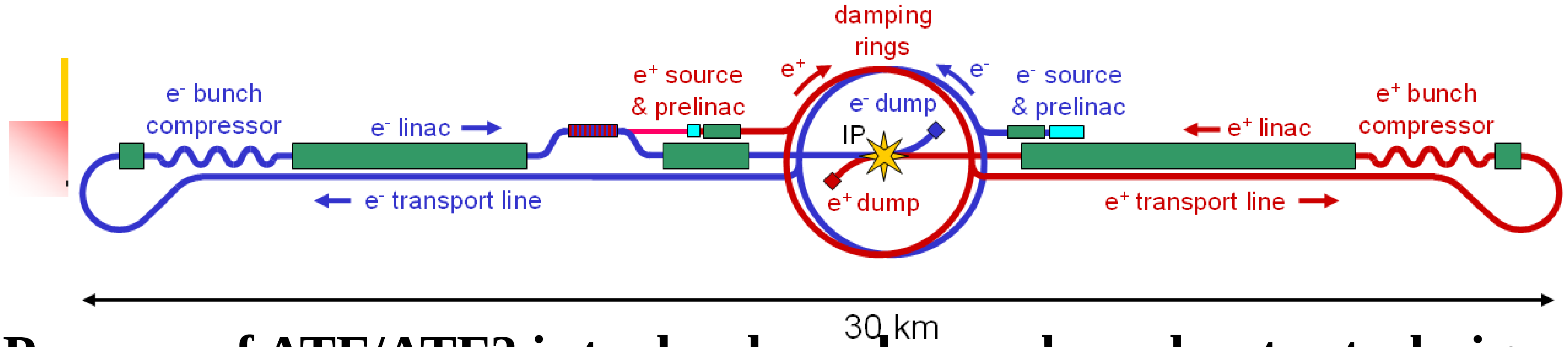
Status of ATF/ATF2

Junji Urakawa (KEK)

for

ATF International Collaboration

ILC RDR Configuration



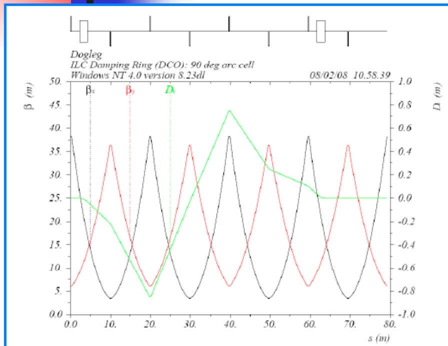
Purpose of ATF/ATF2 is to develop advanced accelerator technique for high intensity and very flat e$^-$/e$^+$ beam related to ILC beam source and beam delivery system.
Especially, aim of ATF2 is to demonstrate realization of 35nm beam for long period.

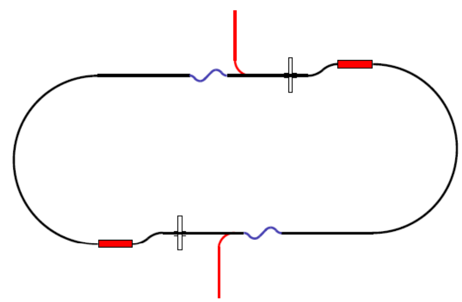
- **Two 6.7 km, 5 GeV damping rings.**

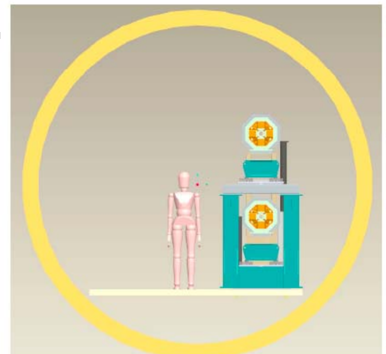
  One electron ring and one positron ring in a shared tunnel around the interaction region.
- **Damping rings area system includes short sections of injection and extraction line, connecting each ring with the sources (upstream) and the RTML (downstream).**

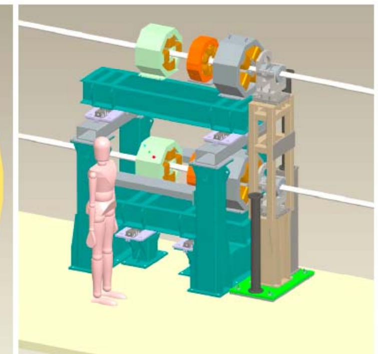
Damping Ring Lattice Selected at Sendai GDE meeting

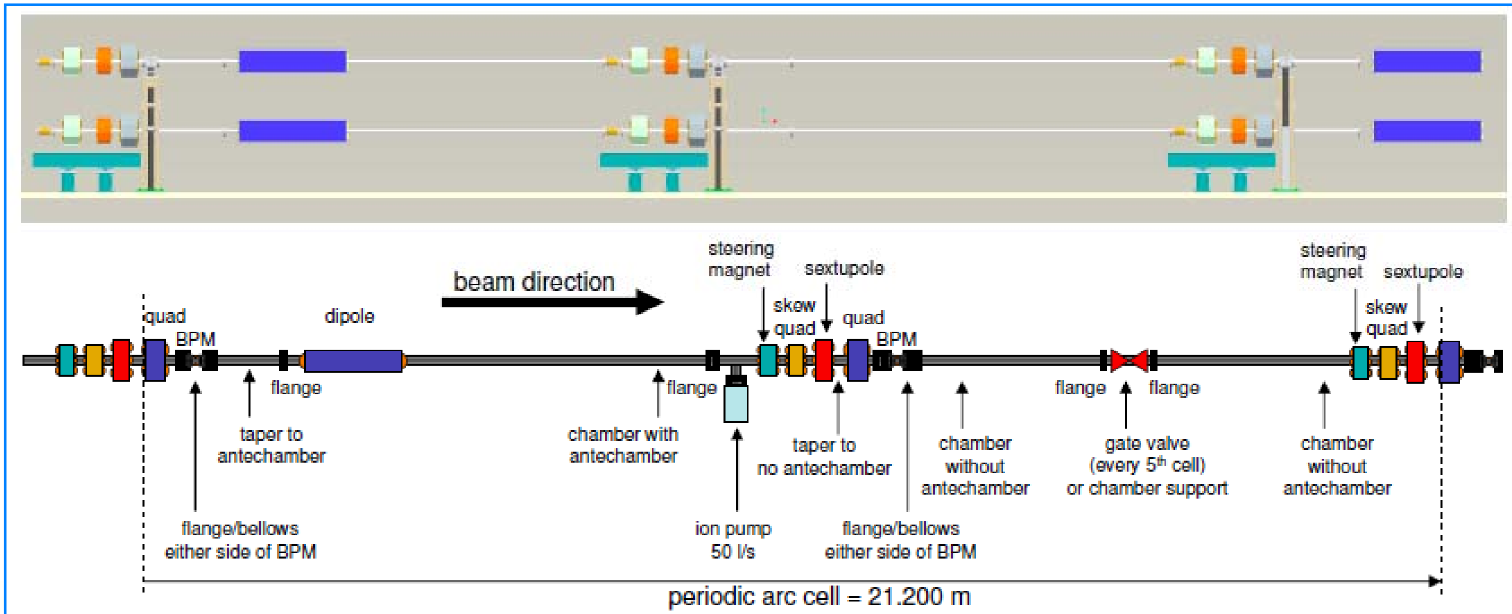
We are under EDP(Engineering Design Phase)-1









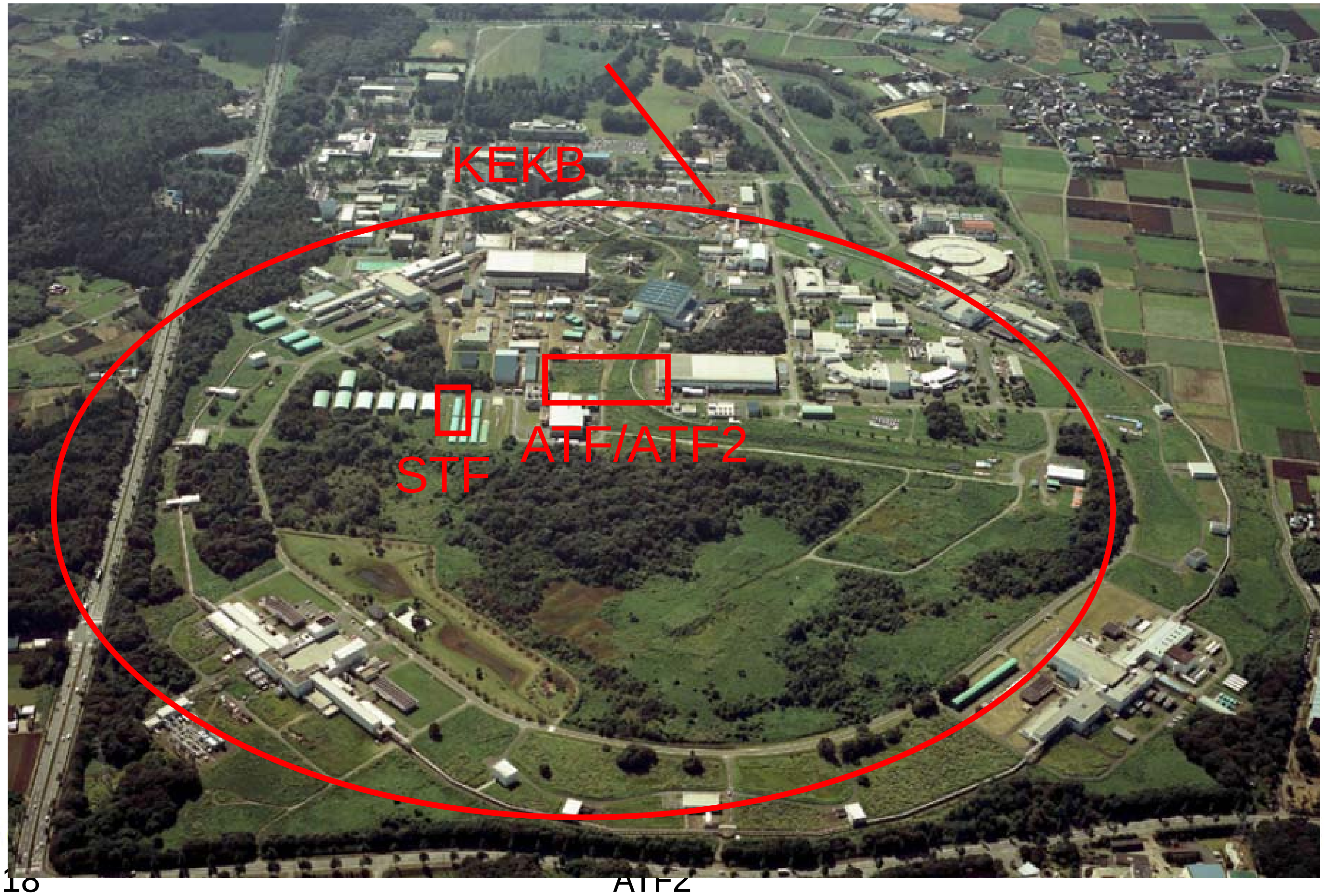


KEK has 3 large facilities for ILC R/D.

ATF/ATF2 : DR, BDS, instrumentations, etc

STF : SC linac

KEKB : DR, conventional e+ source



ATF (Accelerator Test Facility)

The ATF international collaboration include more than 200 researchers and the ATF MOU is signed by 20 institutions from all over the world.

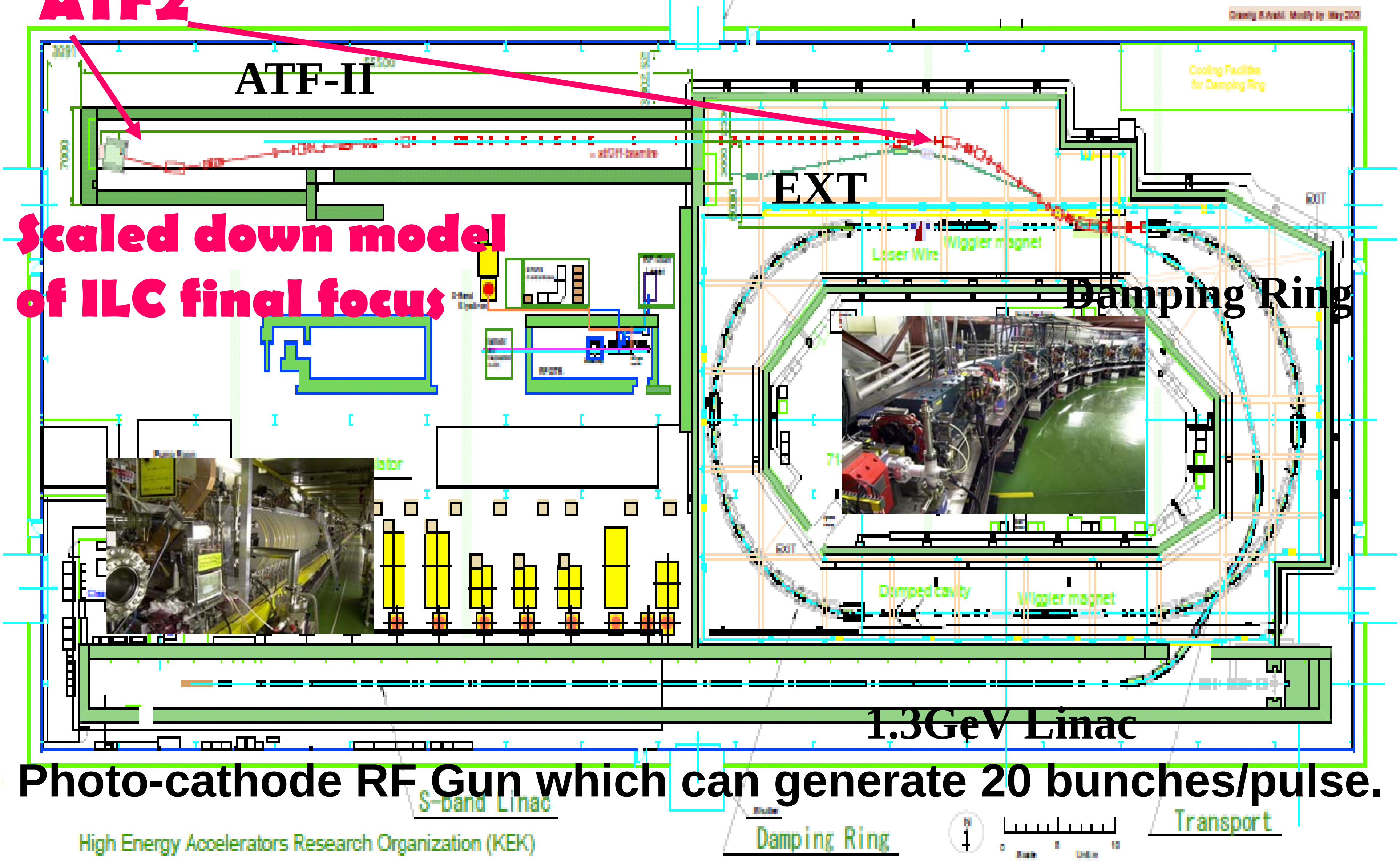


Photo-cathode RF Gun which can generate 20 bunches/pulse.

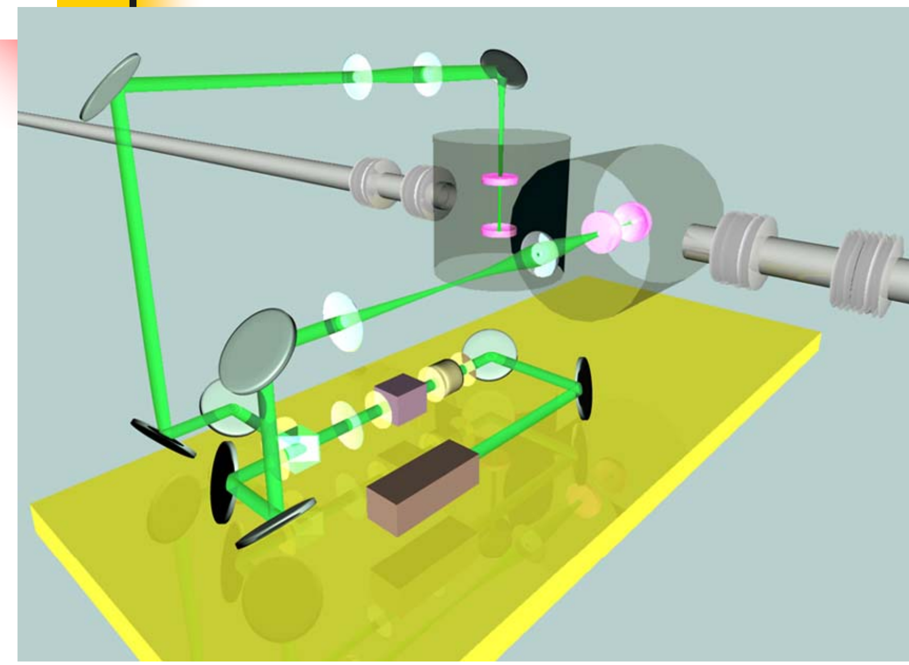
Achievement of ATF

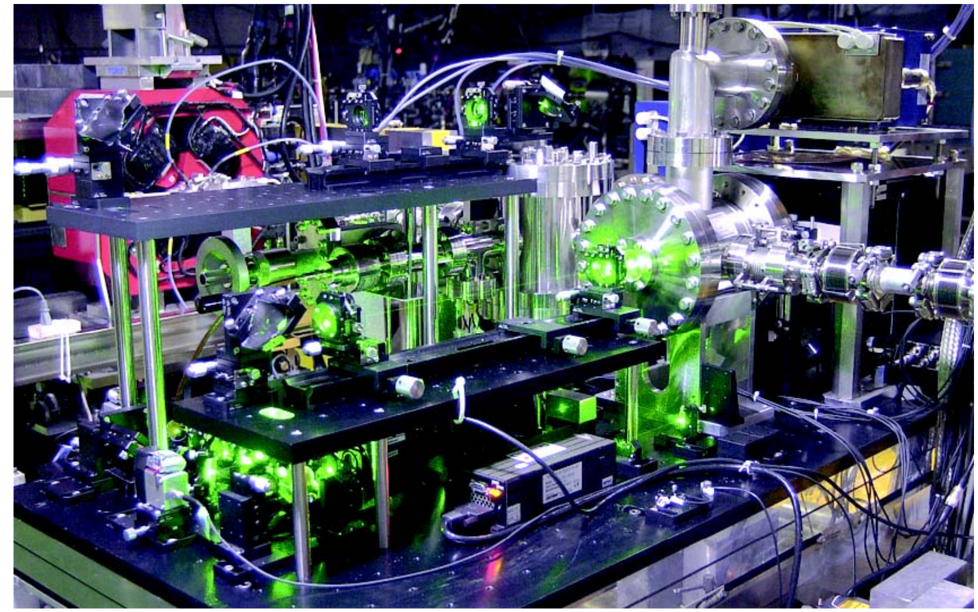
1. **Emittance in Damping Ring.**

   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.** 8nm to 16nm 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.

Laser wire beam size monitor in DR

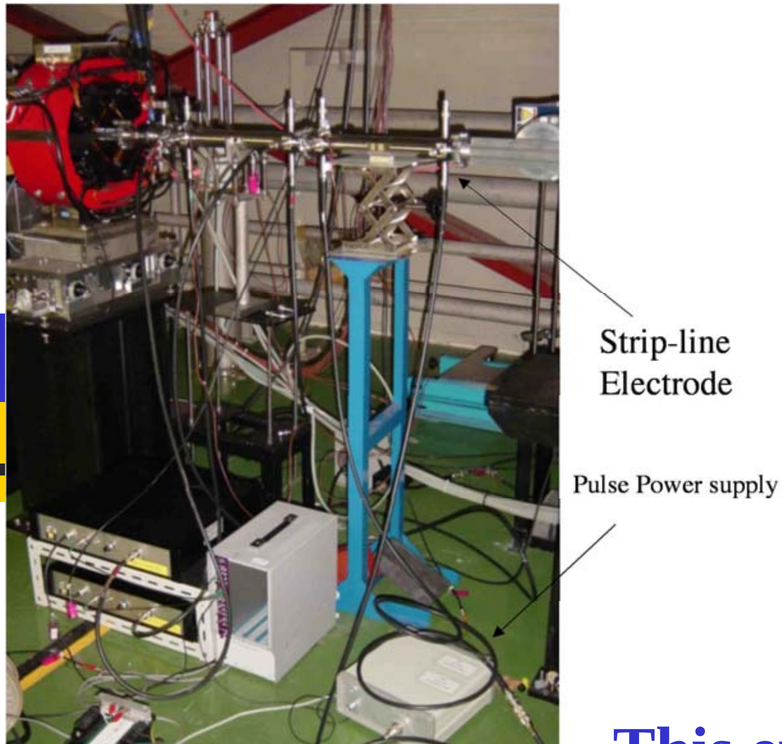


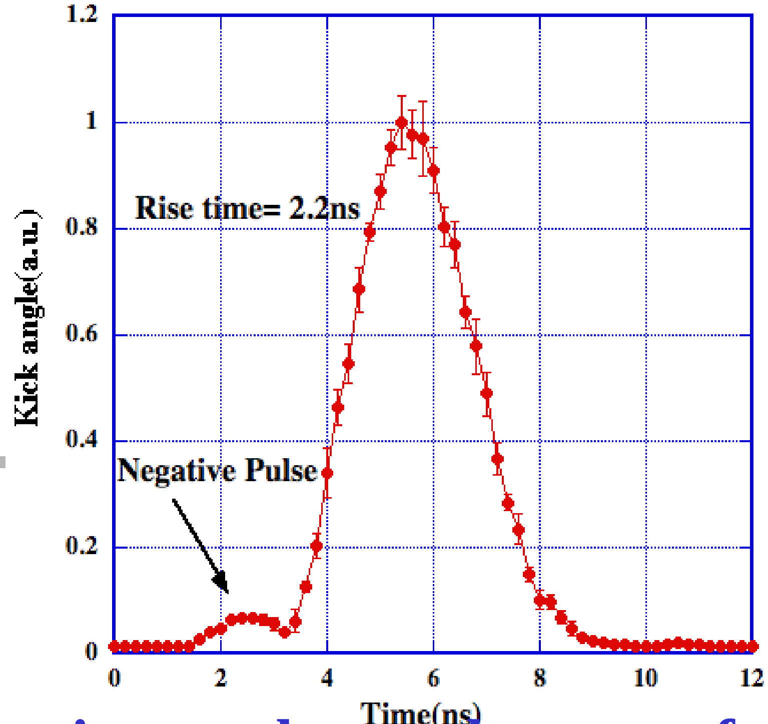


300mW 532nm Solid-state Laser fed into optical cavity

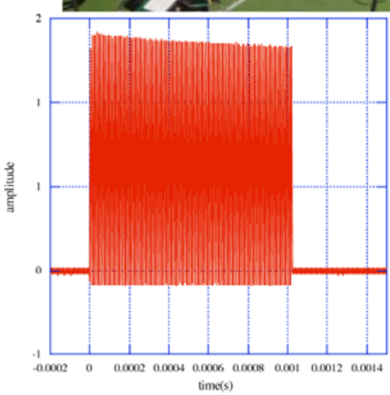
14.7µm laser wire for X scan
5.7µm for Y scan
(whole scan: 15min for X, 6min for Y)

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





This experiment almost shows perfect kick timing control.

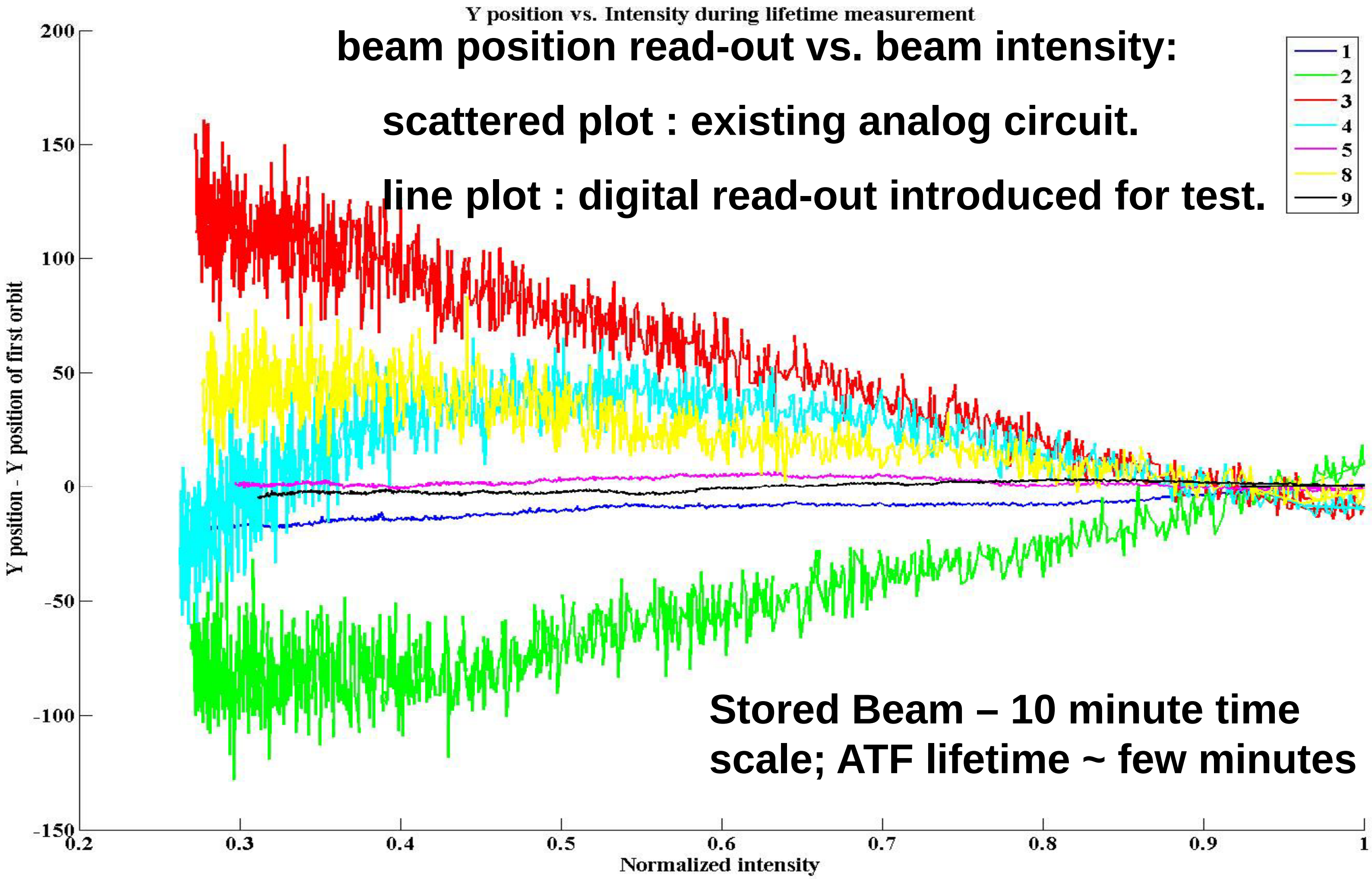


Pulse Train (3000 pulse)
Output from FID Pulser

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:

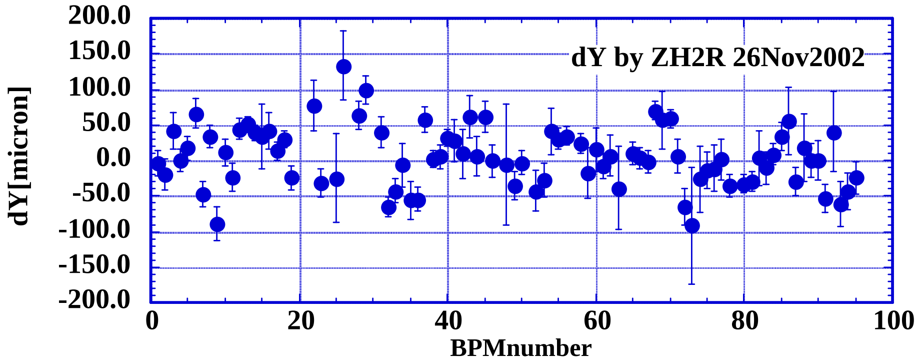
scattered plot : existing analog circuit.

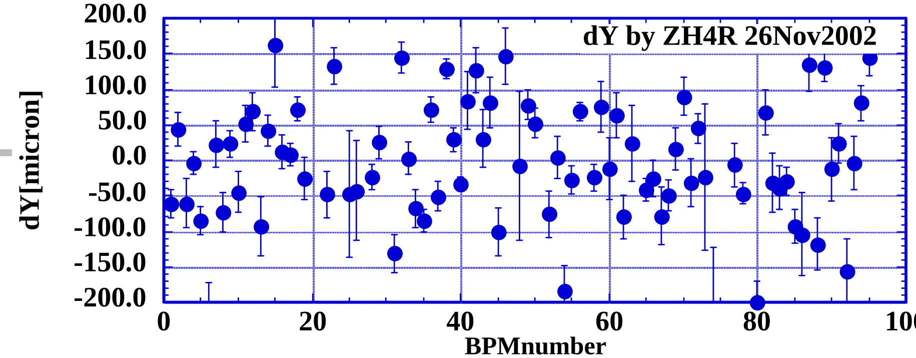
line plot : digital read-out introduced for test.

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

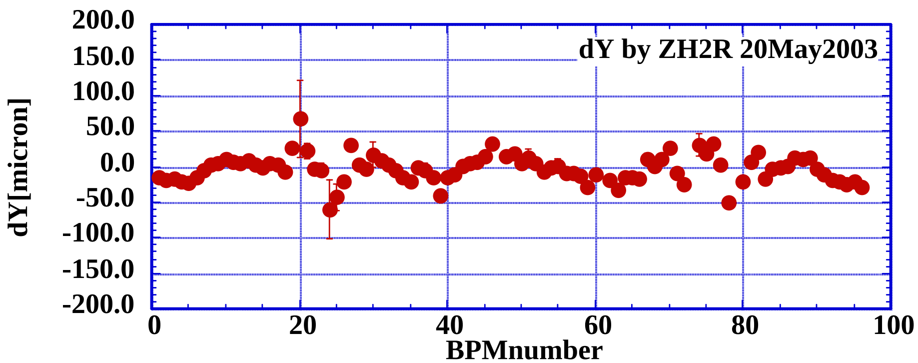
X to Y coupling Improvement

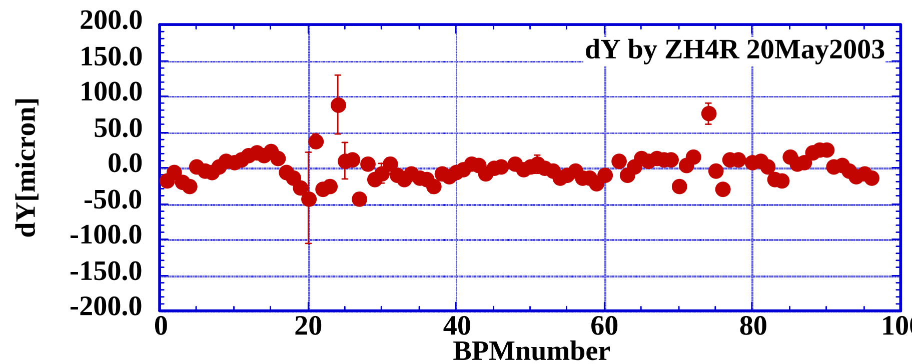
20μm BPM Resolution with old circuit (1997-2002)





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



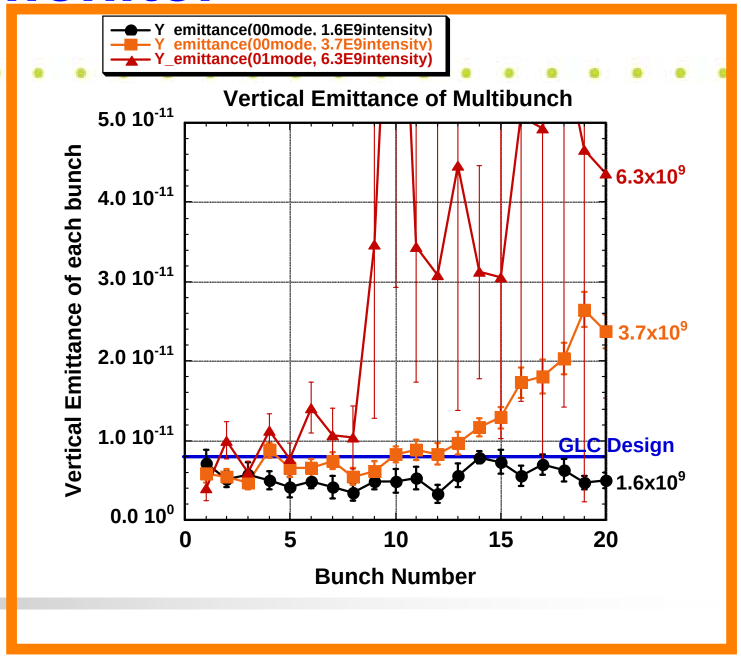


Upgrade of BPM Resolution (~ 0.1μm) with new circuit by SLAC and FNAL. Surely, we will achieve 2pm-rad. Possibly 1pm.

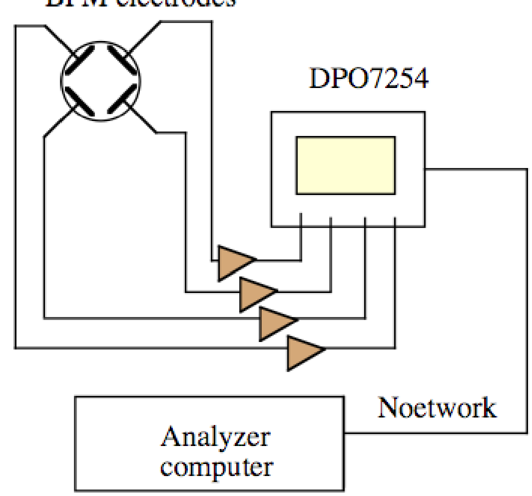
Multi-bunch Turn-by-turn monitor

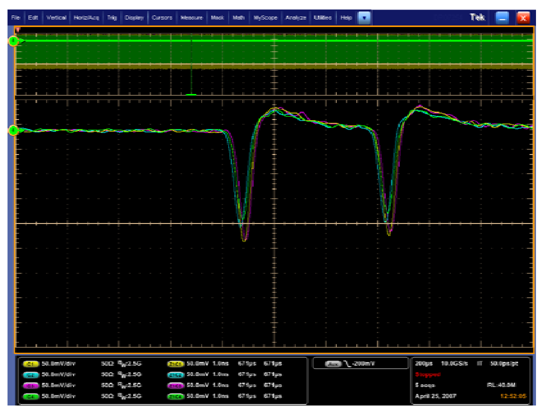
T. Naito (KEK)

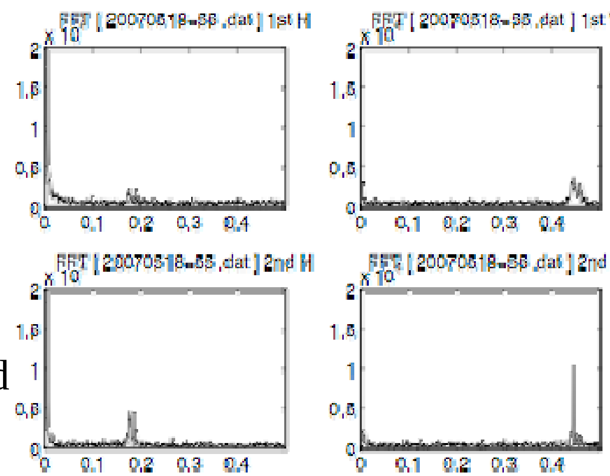
The beam blowup at tail bunches was measured by the laser wire in ATF, which is assumed coming from FII effect. In order to observe the individual beam oscillation in the multi-bunch beam, multi-bunch turn-by-turn monitor has been developed. This monitor consists of front end circuits(amplifier and filter) 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.



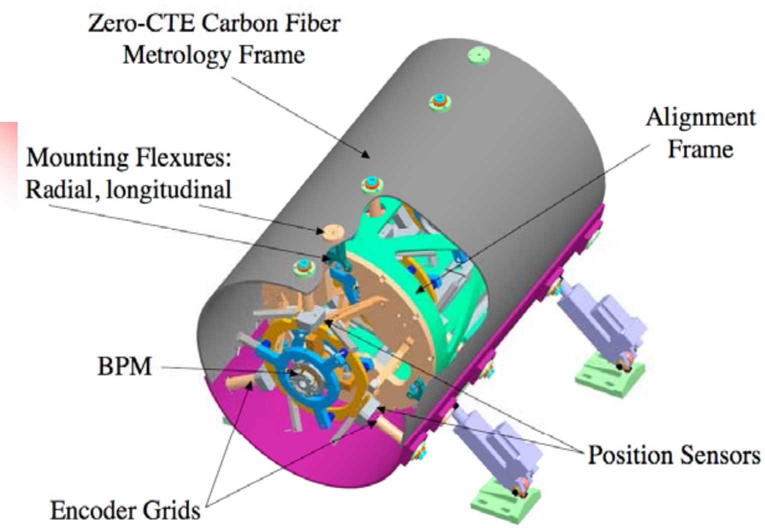


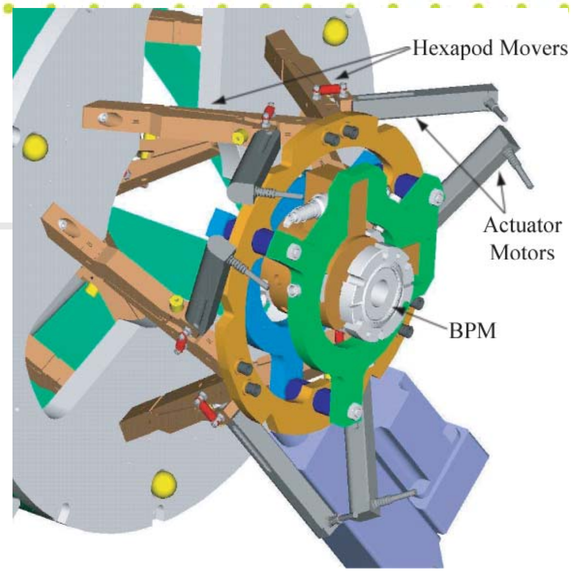


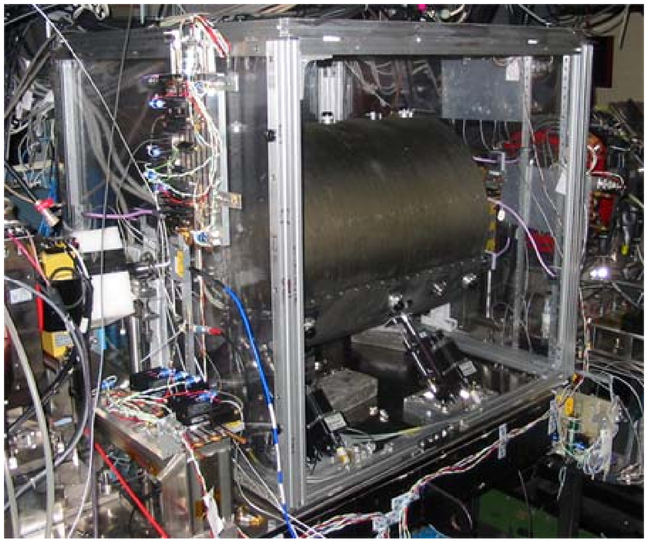
The preliminary results shows the different oscillation amplitude of the tune-X and the tune-Y for the 1st and 2nd bunches at just after injection.

nm resolution BPM

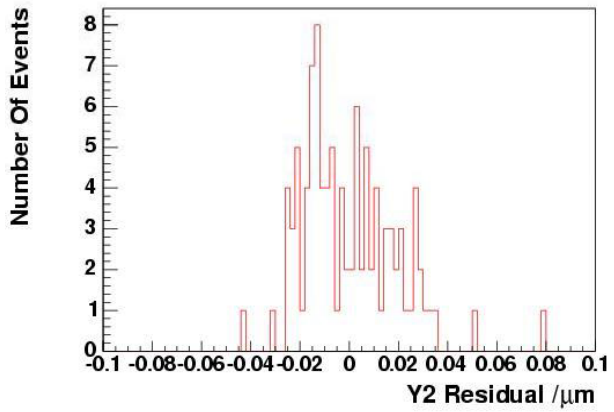
(SLAC, LLNL, UK-University, KEK)







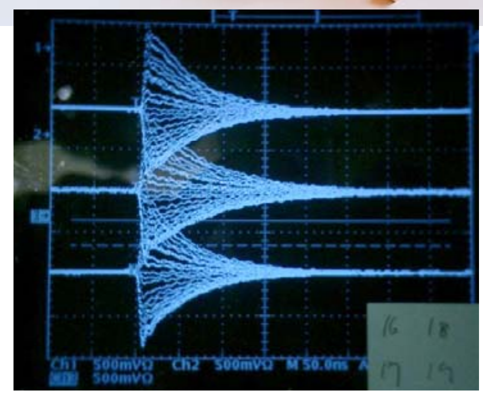
ATF single bunch beam test

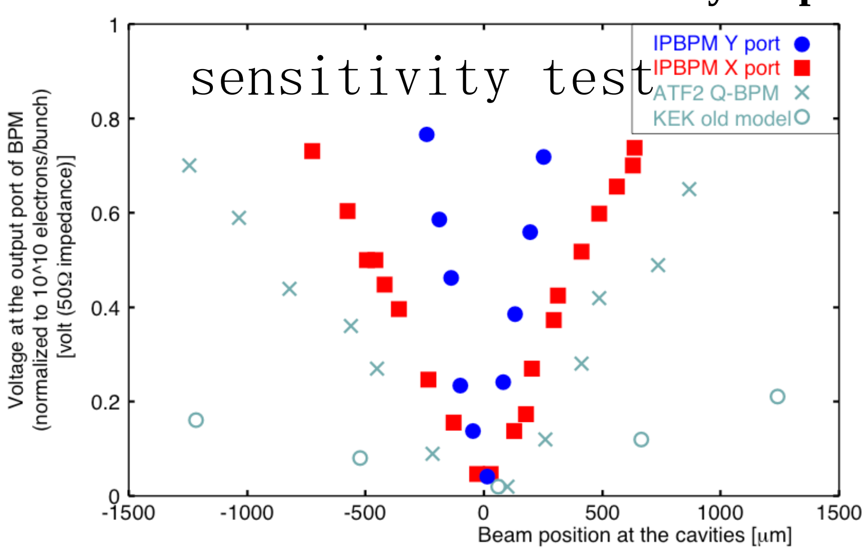


16nm resolution achieved

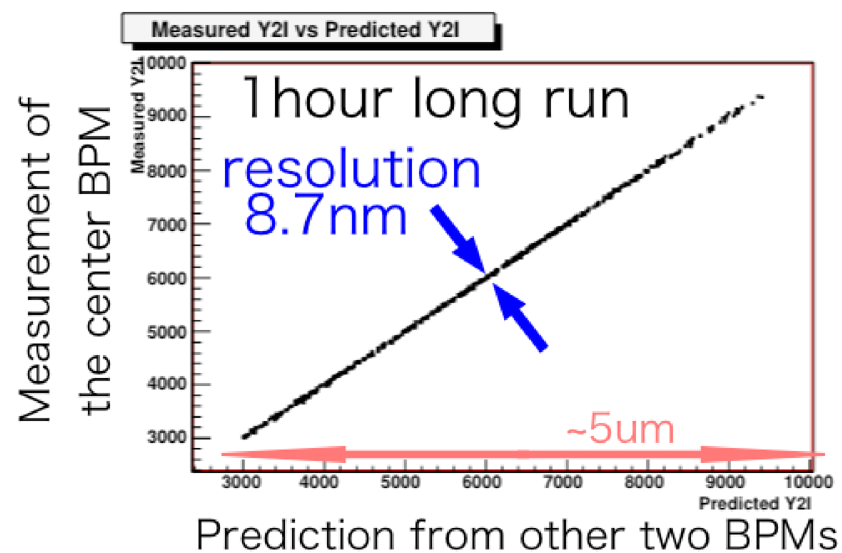
ATF2 IP-BPM

- 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





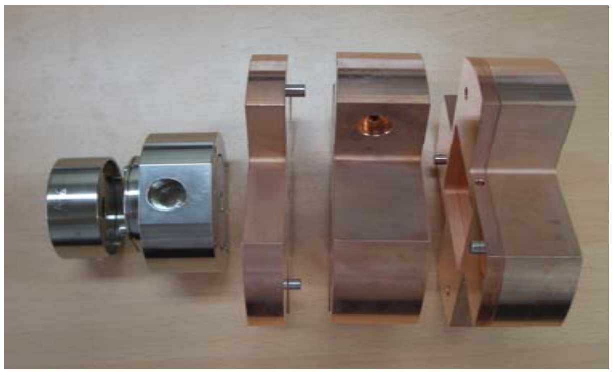
KEK collabo
A

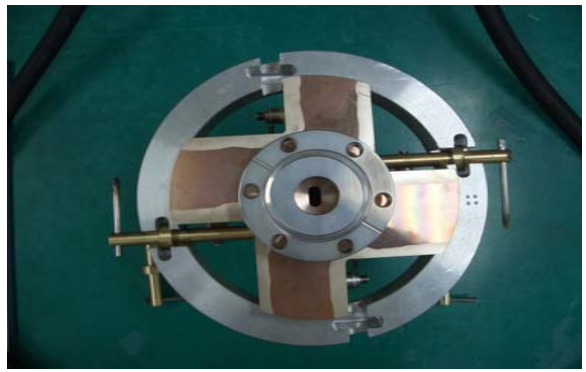


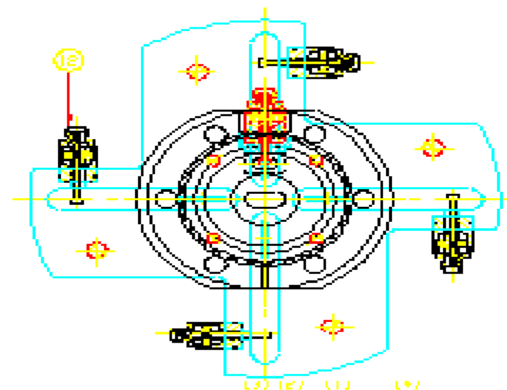
KNU BDS

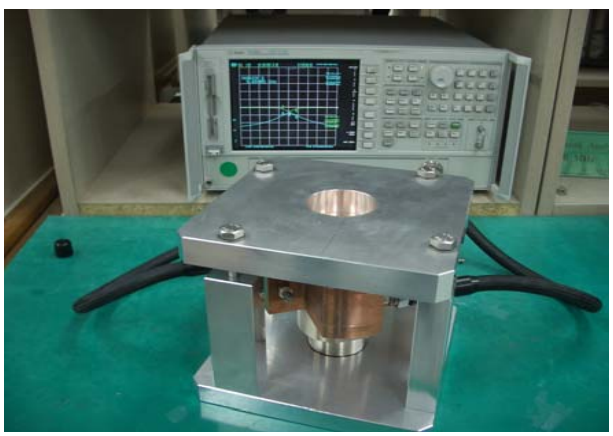
❑ Development of instrumentation for ATF2

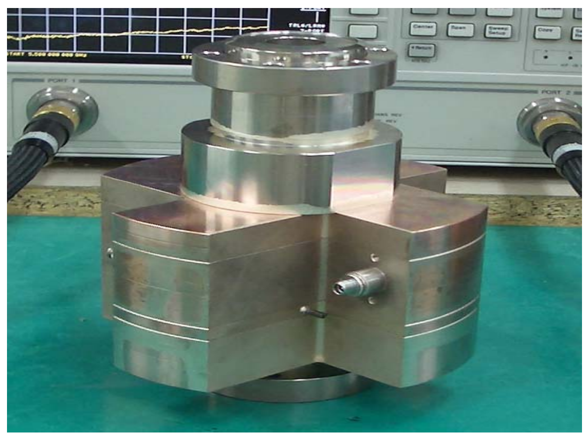
- Design and fabrication of low-Q IP-BPM

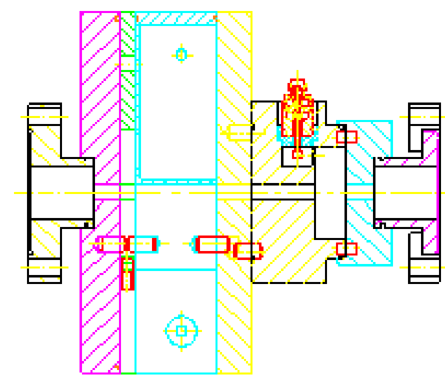








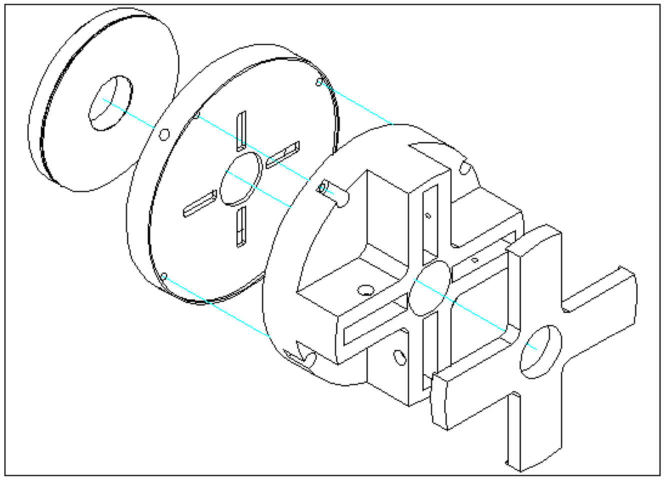


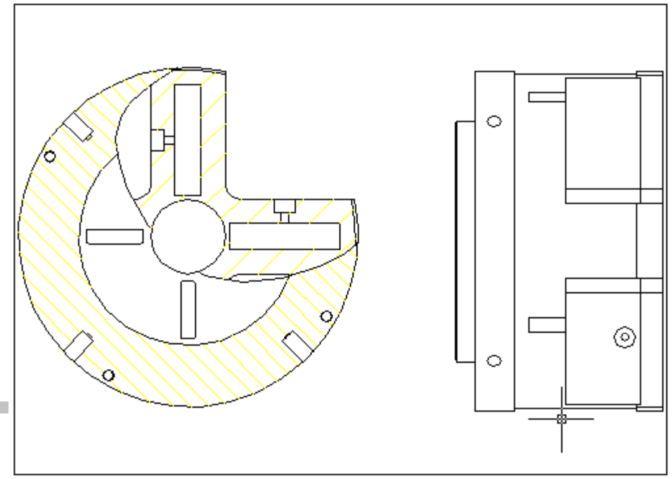


Fabricated in domestic company.
KNU-KEK collaboration

Fabrication of S-band BPM

- 1. Mechanical drawing

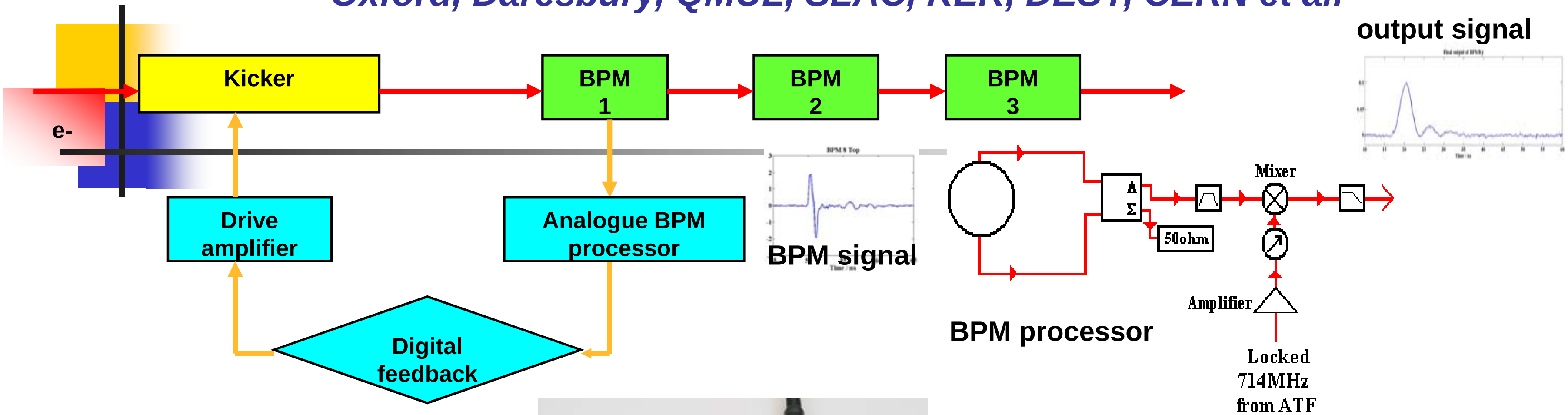




- 2. Machine Shop in KNU

FONT4 : Digital IP feedback R&D at ATF

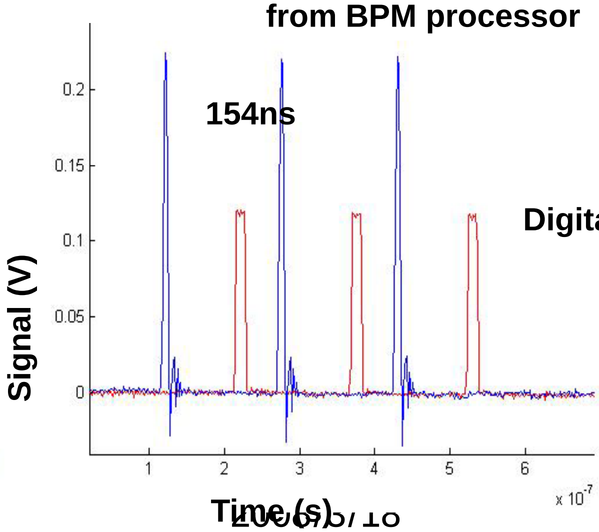
Oxford, Daresbury, QMUL, SLAC, KEK, DESY, CERN et al.

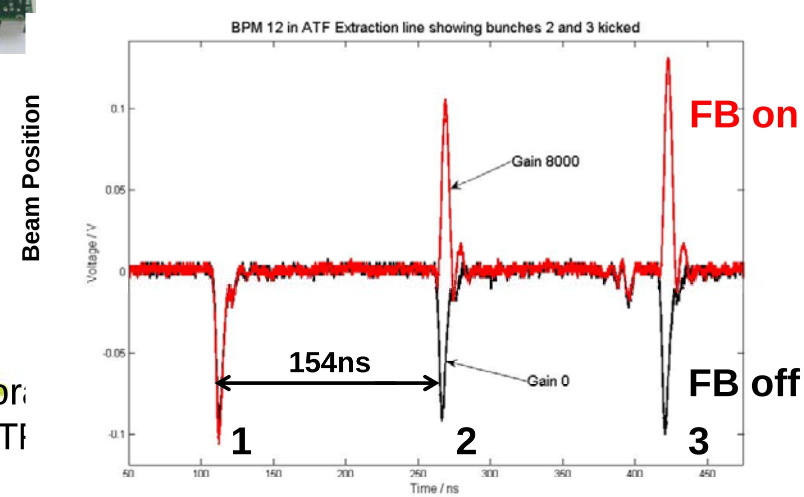


signal pass latency : 25ns
BPM processor:7ns
Digital board:68ns
drive amplifier:40ns *total:140ns*

Digital Board development

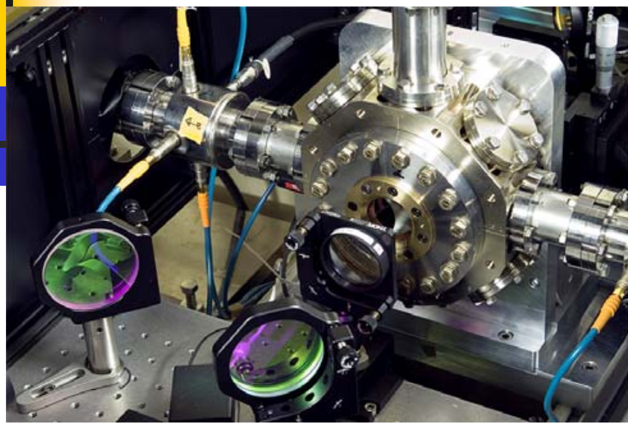
Analogue input from BPM processor

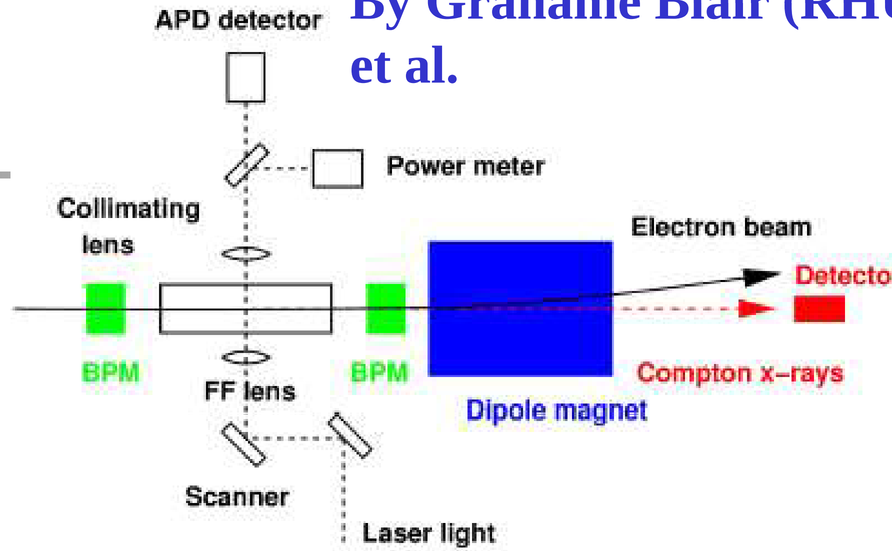


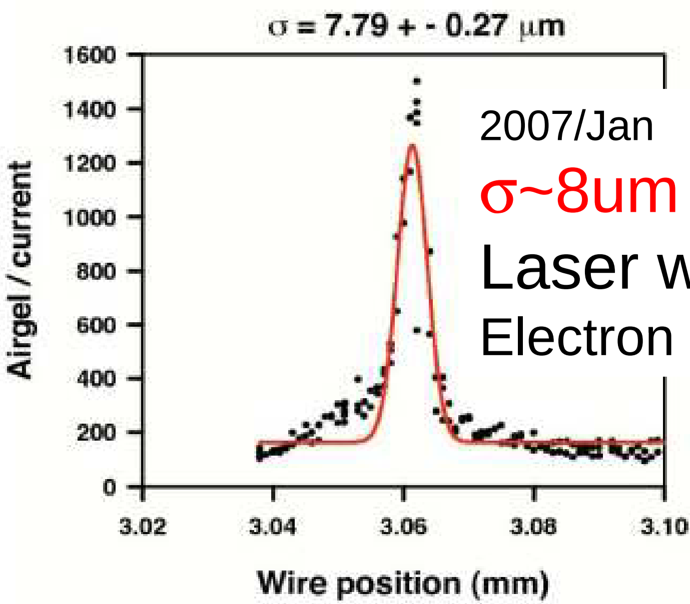


Pulsed Laser Wire R&D

By Grahame Blair (RHUL) et al.







2007/Jan

σ~8um

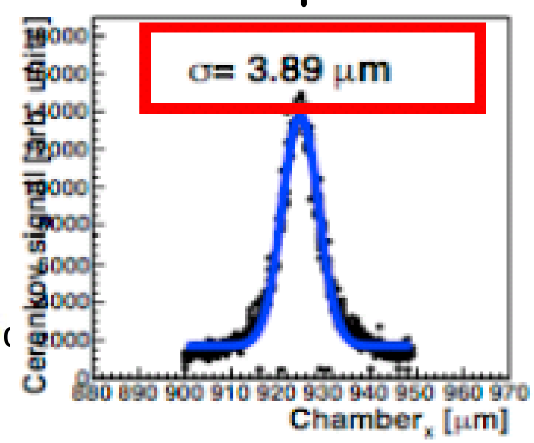
Laser waist :large

Electron beam:σ~1um

ILC design requirement:

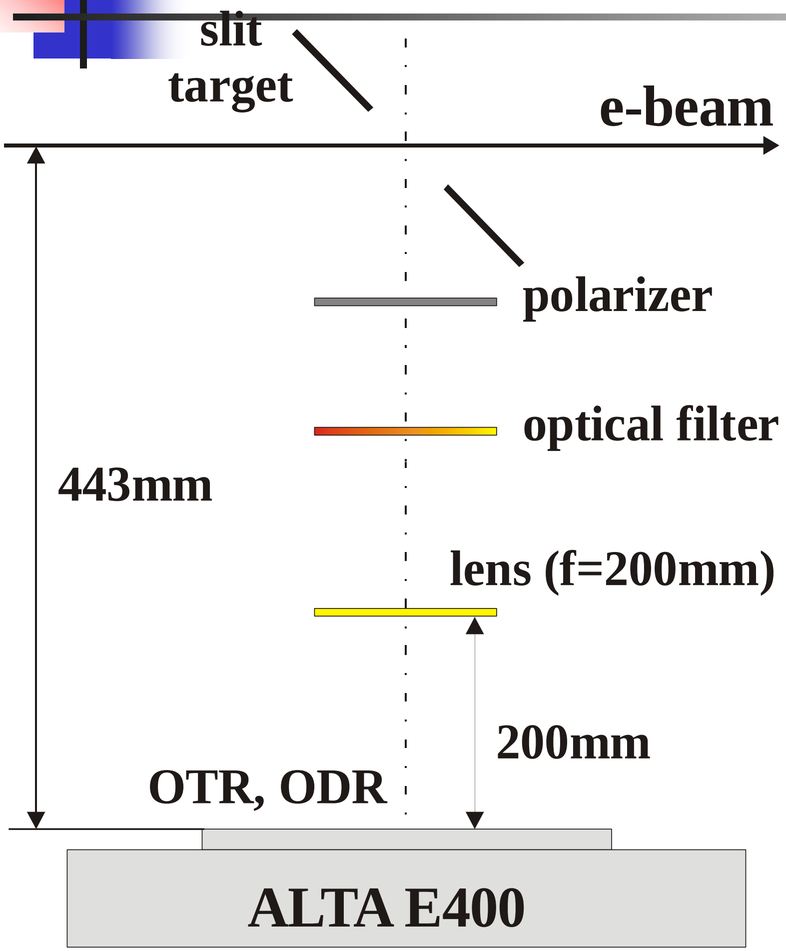
≤1 μm laser wire scanner

2007, Dec. 3.89μm

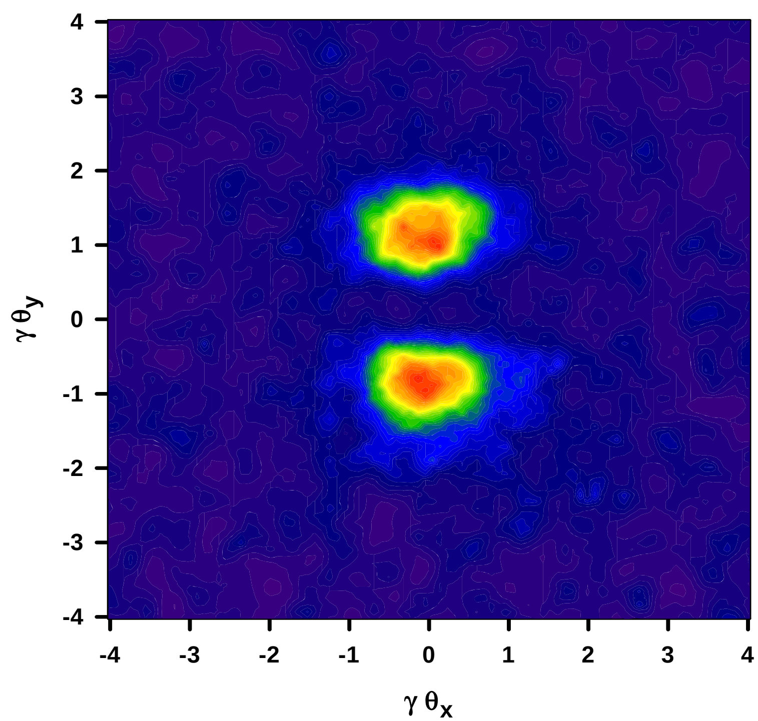


Optical Diffraction Radiation (ODR) beam size monitor (BSM) at KEK-ATF

Experimental layout



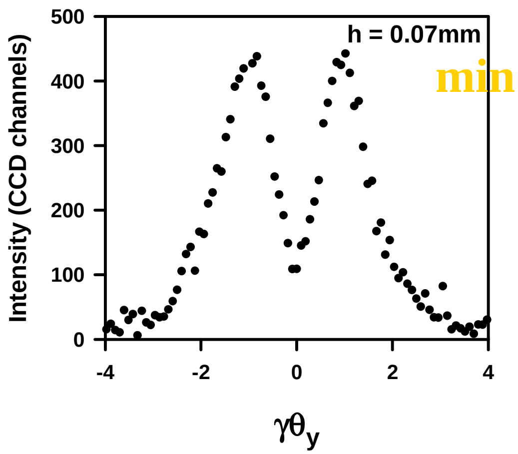
Typical CCD image of ODR vertical polarization component

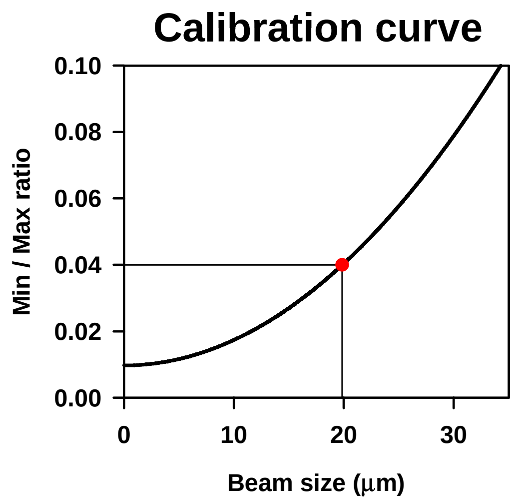


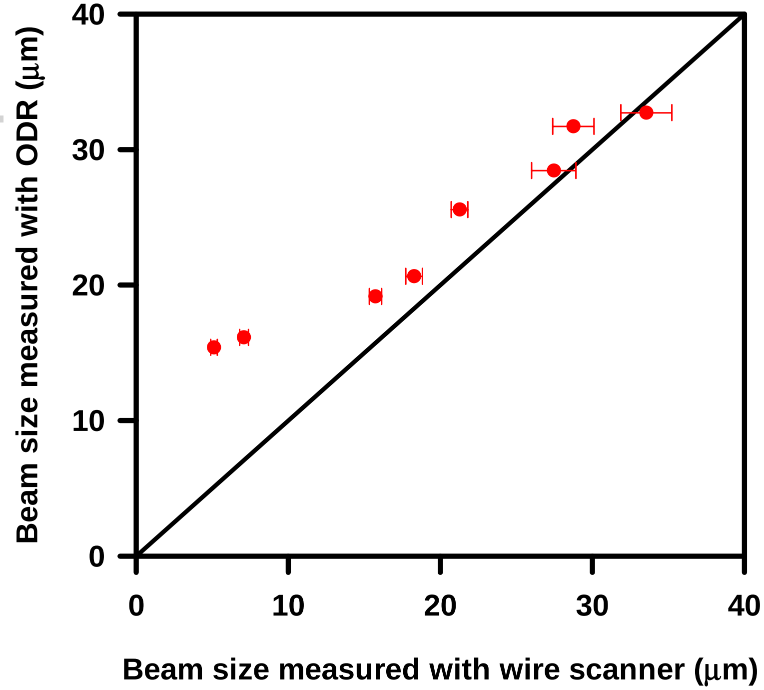
Single-short beam size measurements using ODR

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

- 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

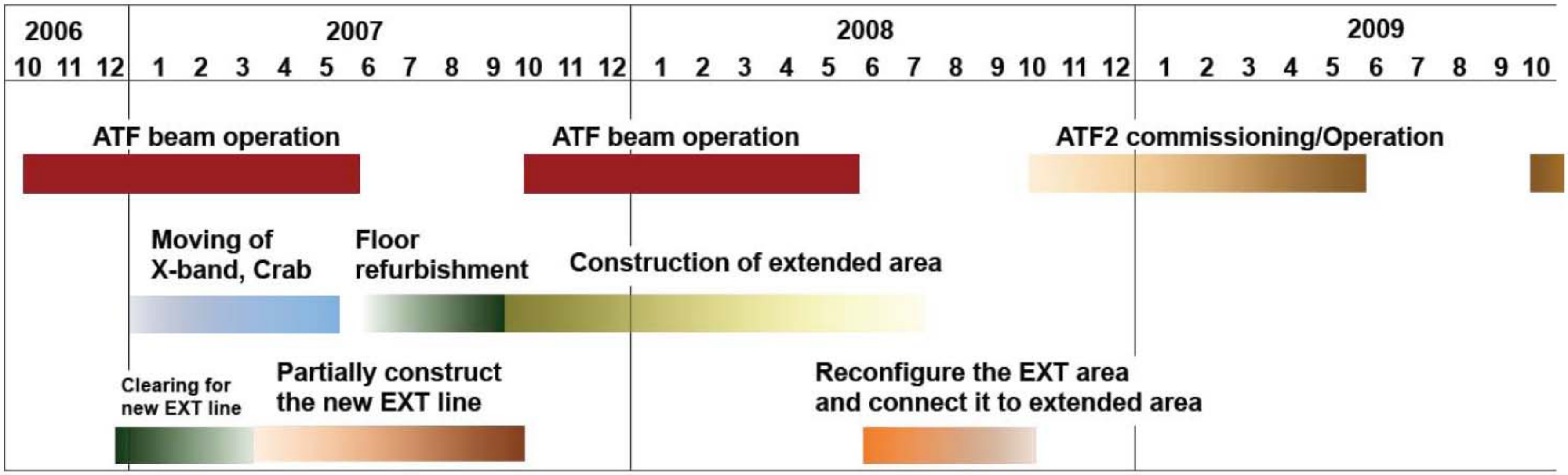
ATF-II Status for BDS R&D

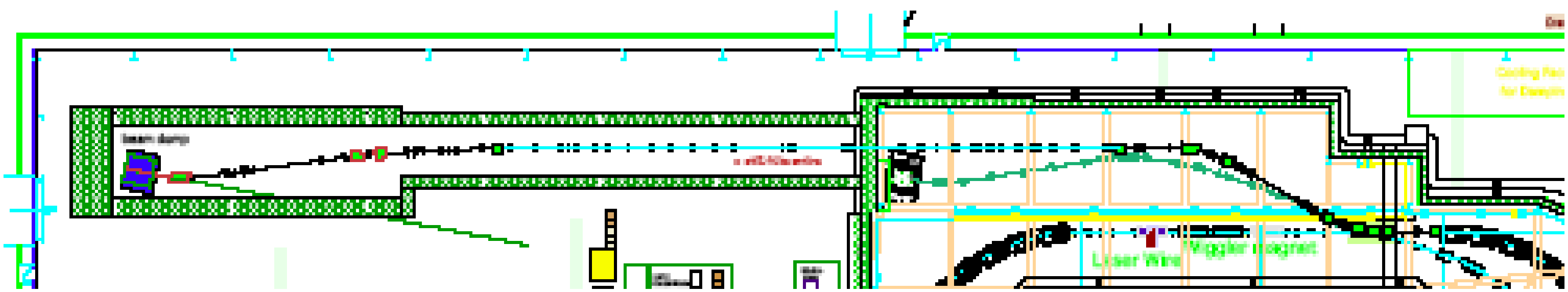
ATF-II Project (35nm Final Focus beam line)

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.)**
- **Flight Simulator R&D program started.**

ATF2 construction schedule





- ATF2 beam will come in October, 2008.

ATF2 construction – rapid progress in 2007

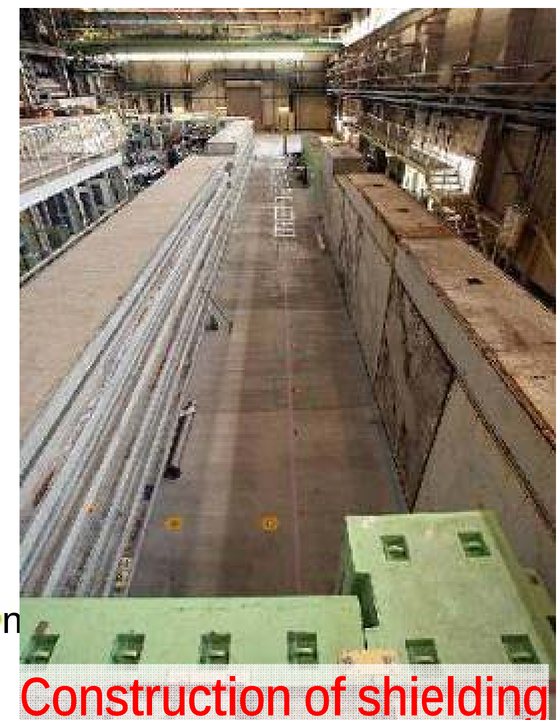
May – December

Assembly hall before construction

Assembly hall emptied for construction

Photos:
Nobu Toge

Construction of reinforced floor



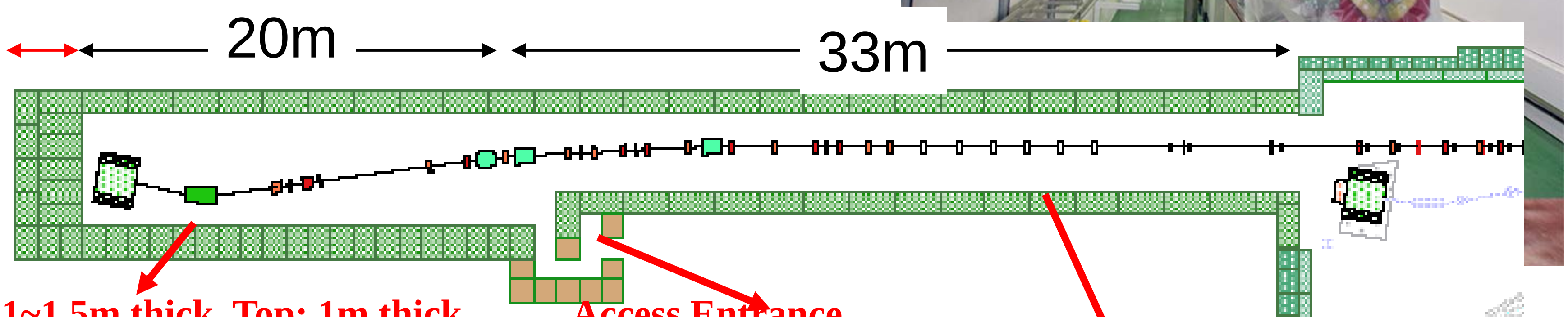
Construction of shielding

ATF2 construction – January 2008

The last regular quadrupole was going to the destination.

~20 sets of supports, movers & quads were installed in January. R.Sugahara et al.

ATF2 construction present status



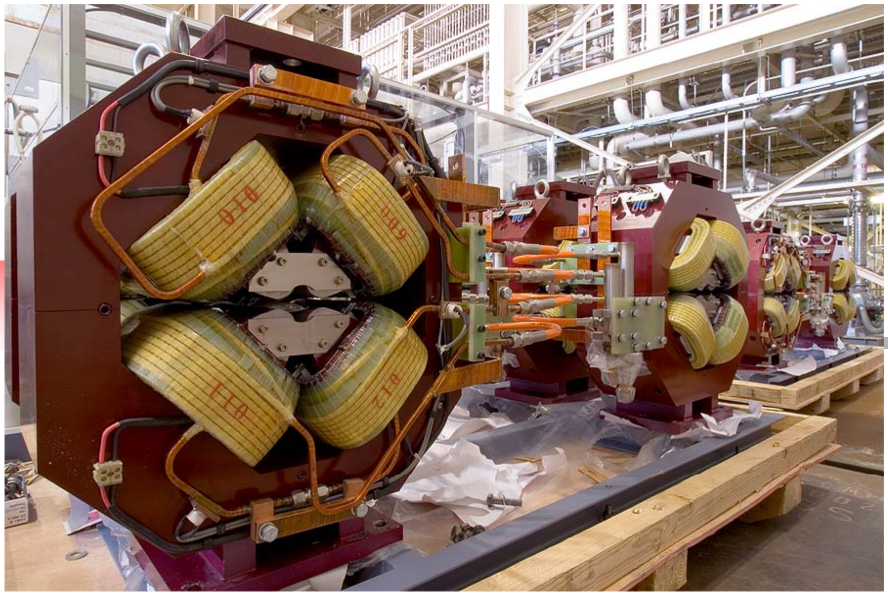
Side: 1~1.5m thick, Top: 1m thick
Inner width: 5m

Access Entrance

Moving shield door

Side: 1m, Top: 0.5m, Inner width: 3.5m

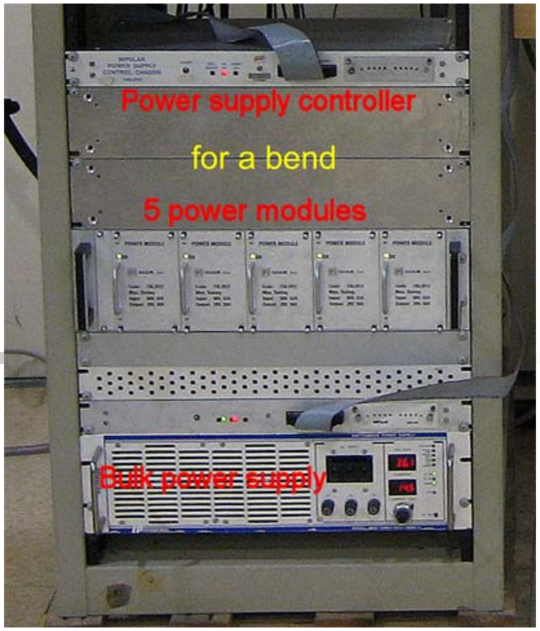
ATF2 development Highlights



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

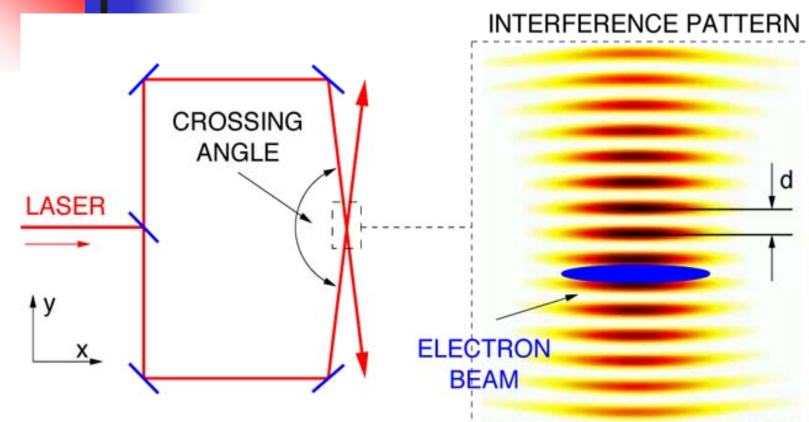


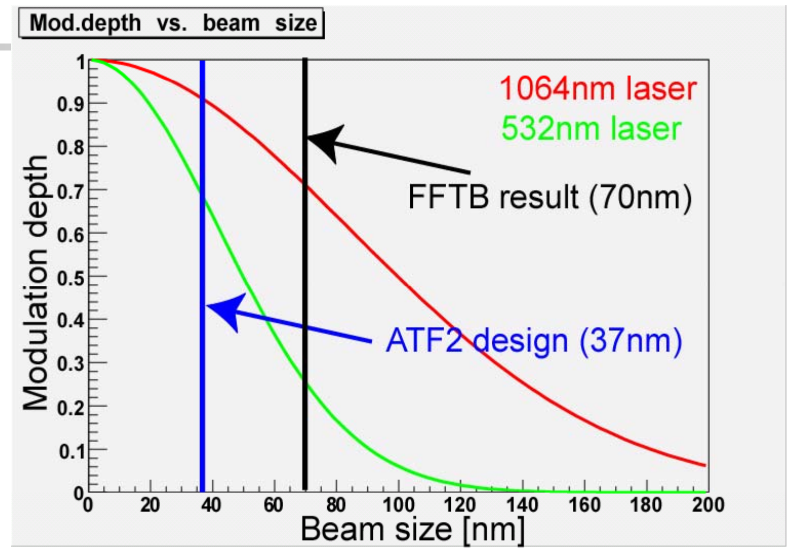
BPM electronics for cavity-BPM (SLAC)
Unit was tested in ATF.
Delivery in 2007.

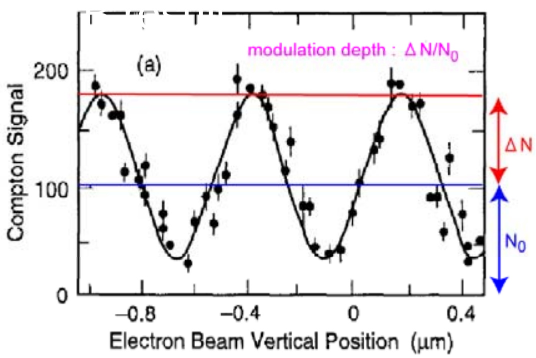
High Availability P.S.
for Q-mag, Bend and Sext (SLAC)
1 unit was tested.
Delivery in 2008.

ATF2 development Highlights

Laser Interference Monitor at ATF2 IP(Tokyo Univ.)







Shintake-monitor result in FFTB

Shintake-monitor from FFTB

FFTB ~70nm -> ATF2 35nm

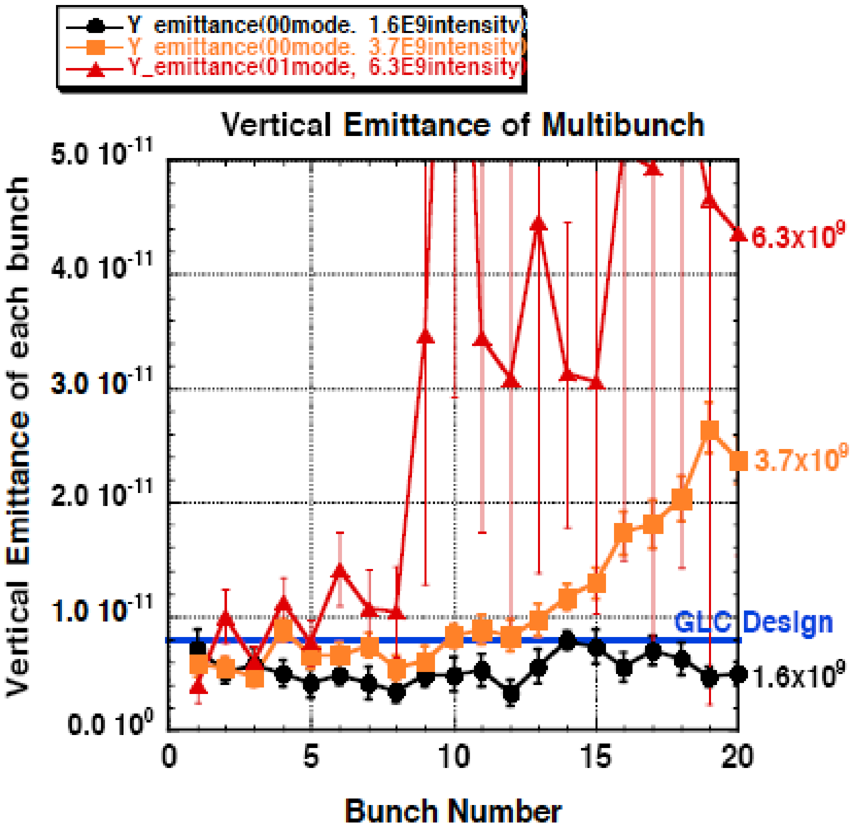
modification : Laser wavelength

fringe stabilization FB

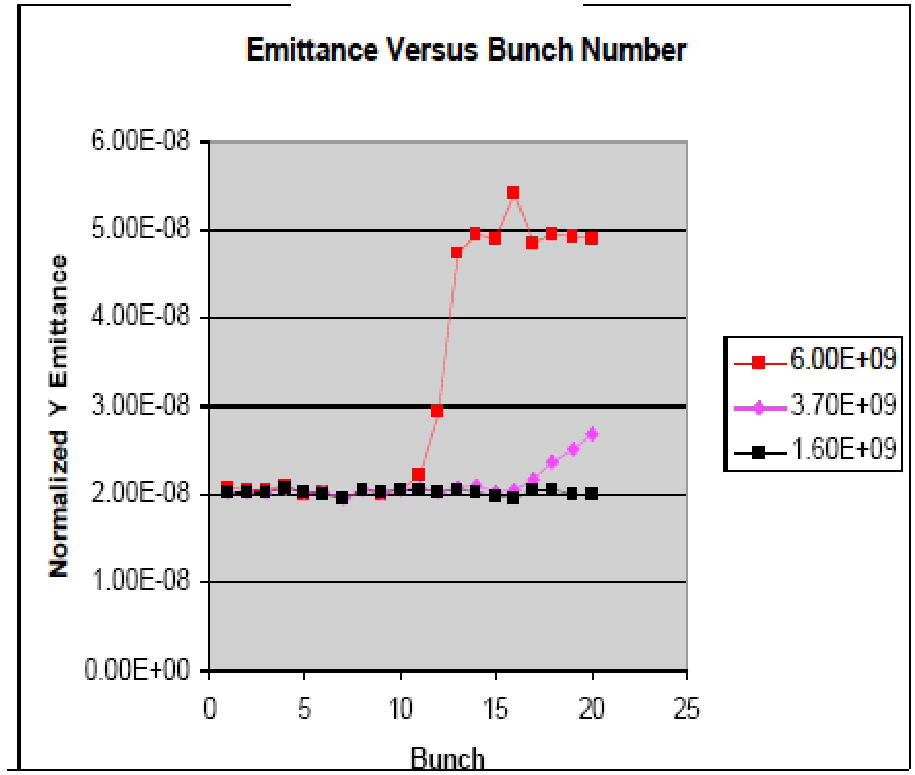
new gamma detector

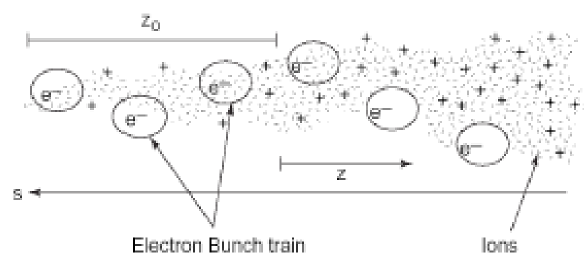
Preliminary result of Fast Ion Instability simulation

Results obtained in 2004



simulation





Schematic of the Fast-Beam Ion Instability

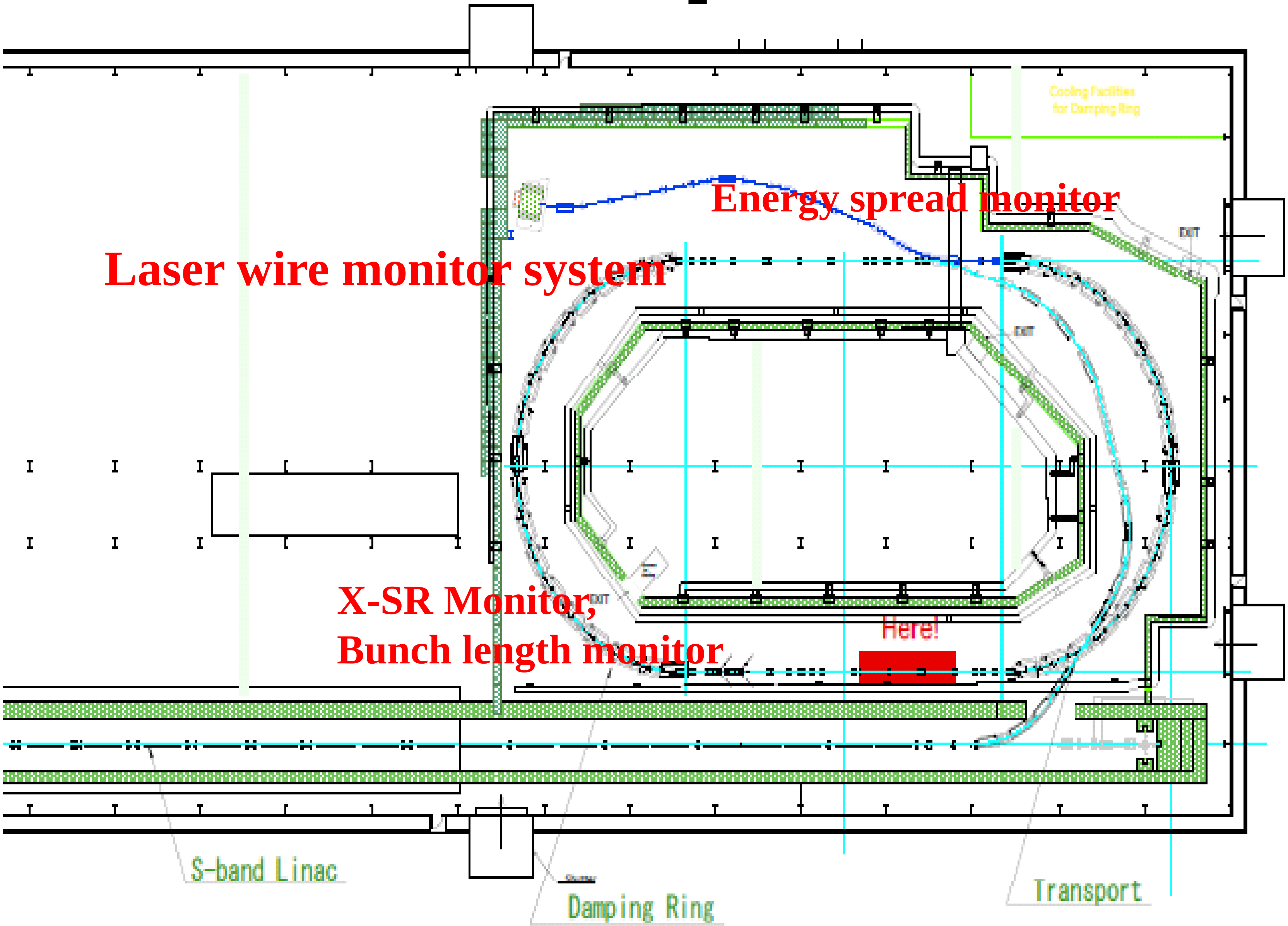
Behavior of Y emittance is very similar.

Problems: meas. of vacuum pressure,
Unknown gas species, extraction kicker heating

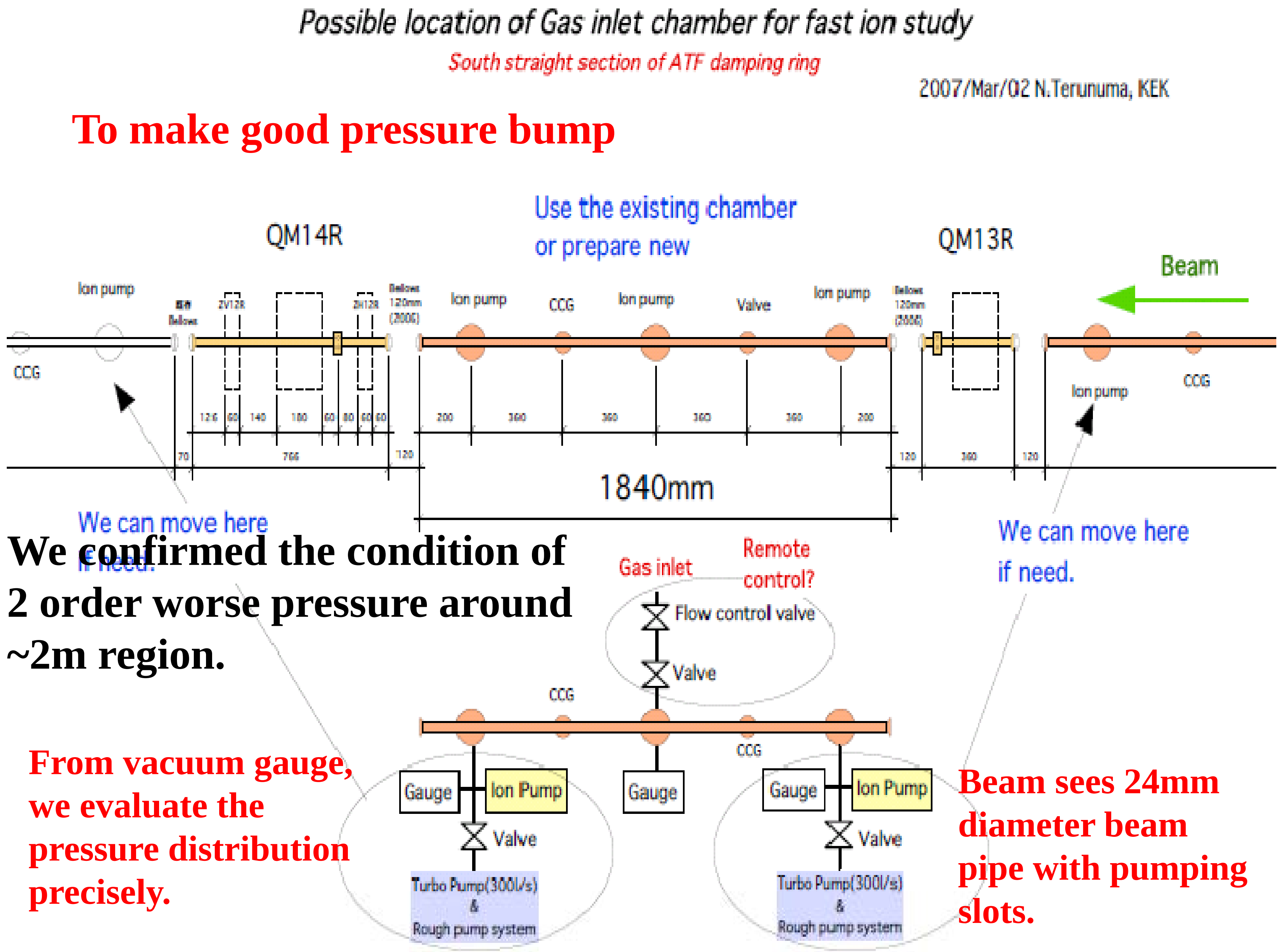
Posssible location for Fast Ion Study

Gas Inlet Chamber : N_2 etc.

2007/Mar/02 N.Terunuma, KEK



To make good pressure bump

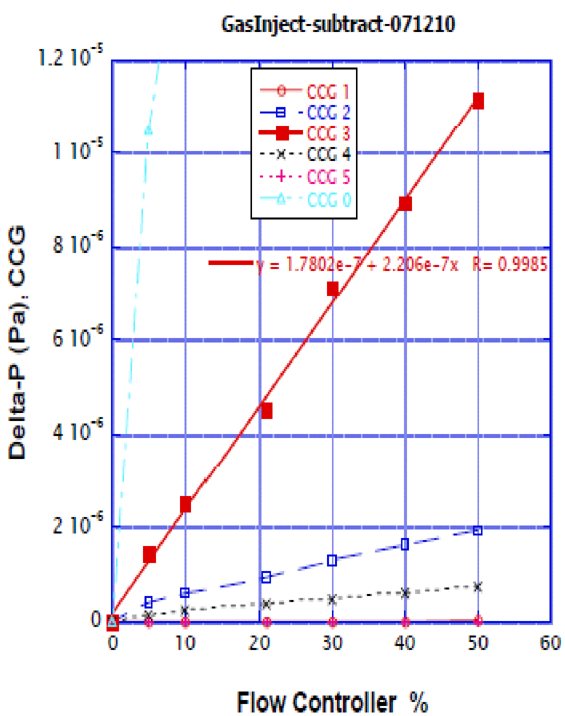


We confirmed the condition of 2 order worse pressure around ~2m region.

From vacuum gauge, we evaluate the pressure distribution precisely.

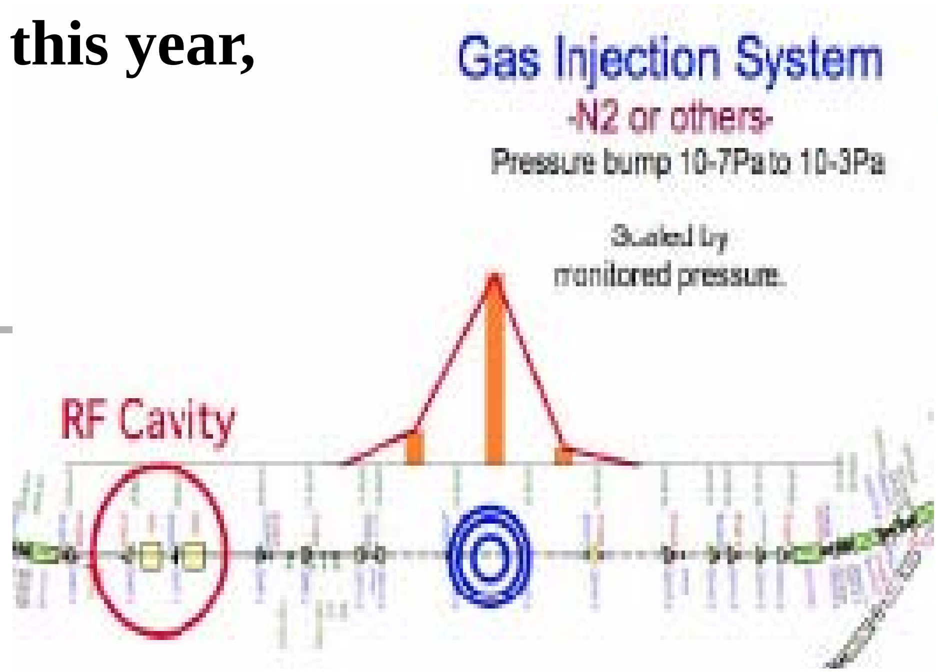
Beam sees 24mm diameter beam pipe with pumping slots.

From the report in this year, by G. Xia (DESY).



(Data come from measurement on Dec 10, 2007)

Gas flow controller in ATF DR



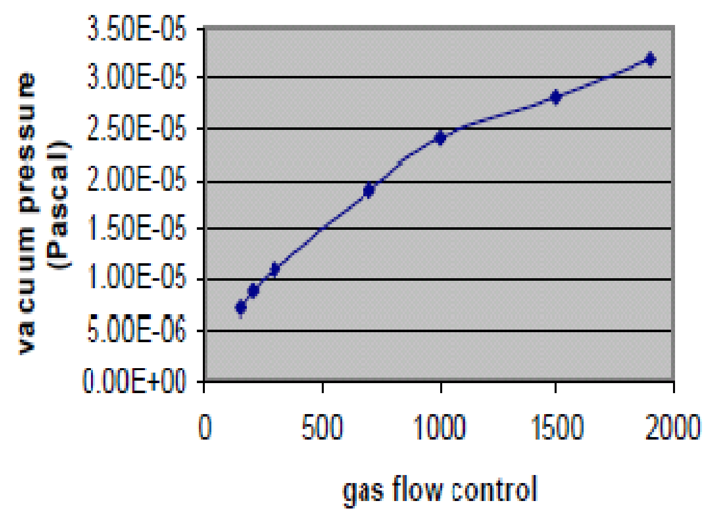


Figure 3: Change the flow controller (Data come from measurement on Dec 14, 2007)

The ultimate goal is to ensure that the design (including specification of feedback system, vacuum levels, and bunch train patterns) is such that the damping rings will be capable of delivering a beam with the required quality.

Achieving the Objectives will involve the following tasks:

1. Validate existing theoretical models and simulation tools for the fast ion instability by carrying out suitable measurements in available storage rings.
2. Refine existing simulation tools beyond their current state or develop new tools if necessary to achieve acceptable agreement with the experiments.
3. Demonstrate the existence of viable machine designs capable of meeting the specifications for beam quality and stability, and show experimental feasibility of these designs using existing machines if possible.
4. Explore the effectiveness of a variety of mitigation techniques (such as clearing electrodes), if necessary.

The main deliverables will be:

Experimental validation of theoretical models and simulation tools for the fast ion instability.

Indication of machine design parameters (including bunch filling patterns, lattice optics, feedback and vacuum specifications) capable of delivering a beam with the required quality and stability without limitations from ion effects.

Guidance for optimization of design of vacuum and feedback systems, and optimization of the optics design, to avoid limitations from ion effects.

If the Objectives are not met, the ability to deliver the required beam specifications at extraction could be compromised, resulting in reduced luminosity.

Plan for fast ion instability study at ATF

- Required information : ion density (related parameters include vacuum pressure, average beam line density, emittance, betatron function and beam fill pattern), bunch train gap, detail data to benchmark simulations with experiment.
- Deliverables : reliable simulation codes to evaluate the vacuum level, fill pattern and bunch-by-bunch feedback system.
- Resources : SLAC, LBNL, KNU, DESY, KEK

Goals of the experiment
(according to Two proposals)
(G. Xia, E. Elsen, L. Wang and T. Raubenheimer)

- Distinguish the two ion effects: beam size blow-up and dipole instability.
- Quantify the beam instability growth time and tune shift. The growth rate is related to the ion density (vacuum pressure, average beam line density, emittance, betatron function and so on).
- Quantify the bunch train gap effect
- Provide detailed data to benchmark simulations with experiment.

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);

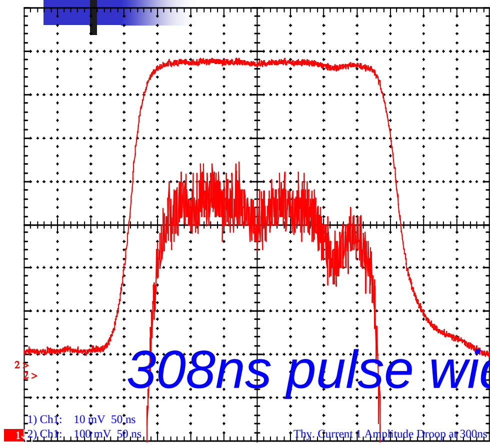
With different beam: 1 train, N of bunch =2~20, $5 \times 10^{9} \sim 2 \times 10^{10}$/bunch

C. Gap effect

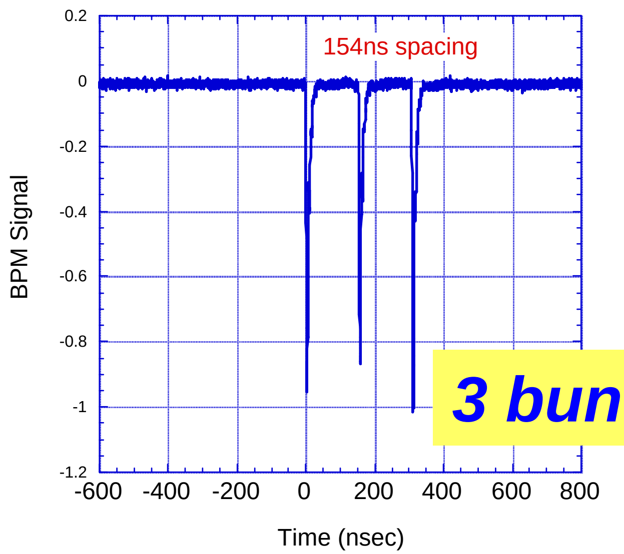
- repeat B with 2 and 3 bunch trains,
- repeat B with different length of gaps.
- repeat above with a different emittance (emittance ratio :changed by skew quads from 0.5% to 10%.)

Design and beam test for strip-line fast kicker experiment

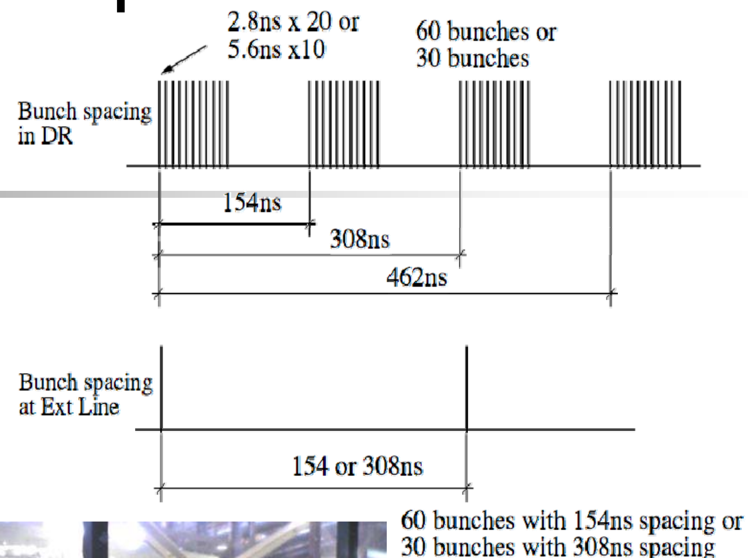
Present kicker stability
(Pulse magnet kicker system)



(Single bunch) x 3 Train Extraction



3 bunches, 154ns spacing

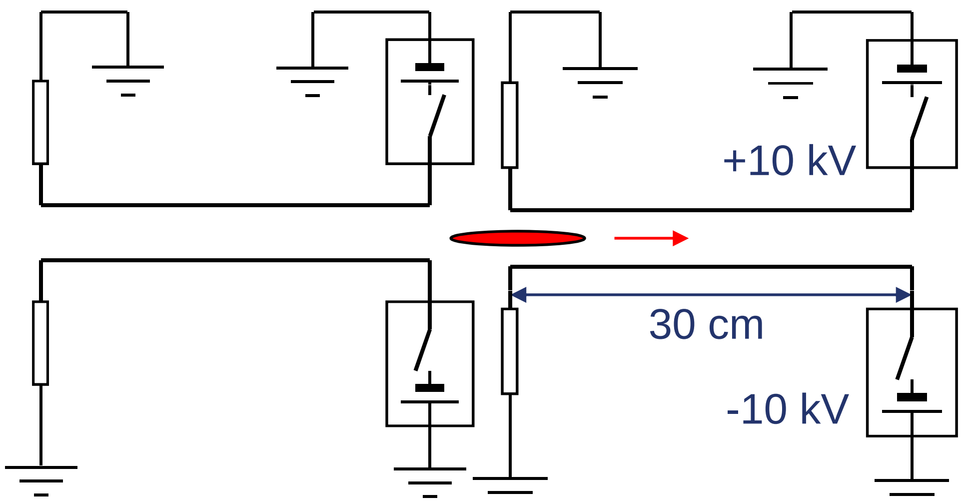


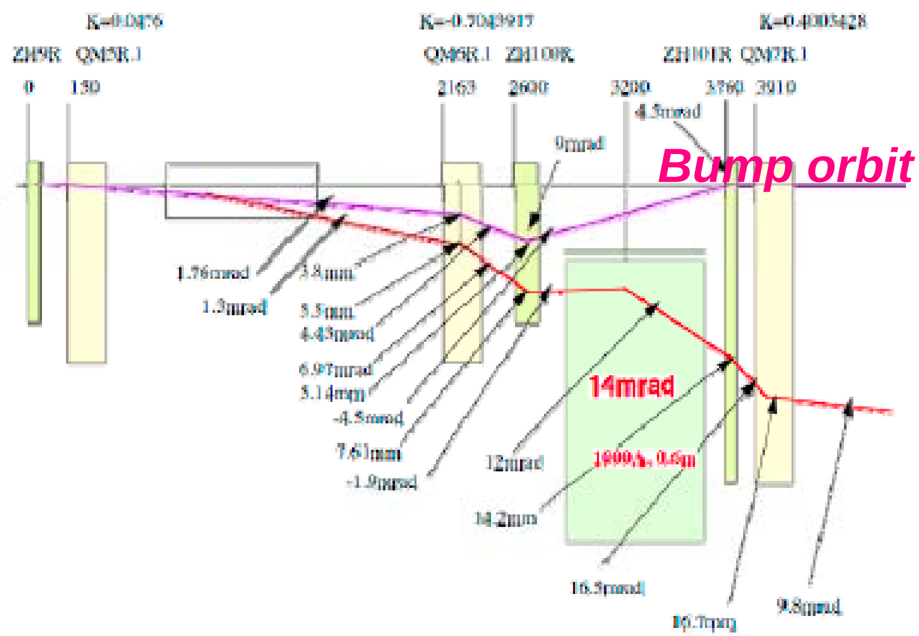
10kV 1ns:rise time, fast Pulse power supplies

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.

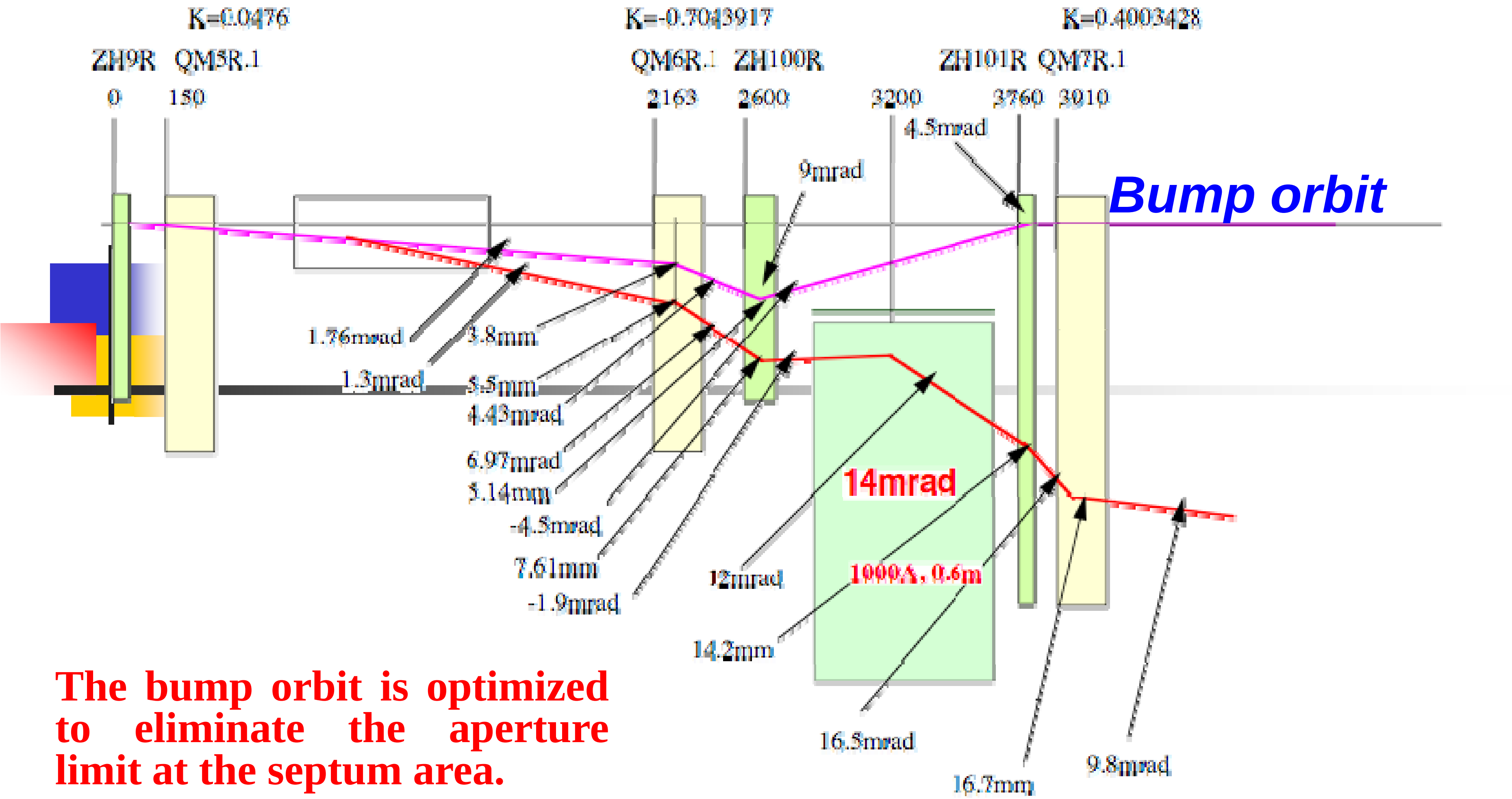




The length of each strip-line is limited by the rise and fall time specifications: the maximum length is approximately 30 cm.
Each strip-line is driven by two pulsers operating at ±10 kV, providing a voltage between the electrodes of 20 kV.

Beam extraction at the end of 2008

Beam 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.

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 2009.

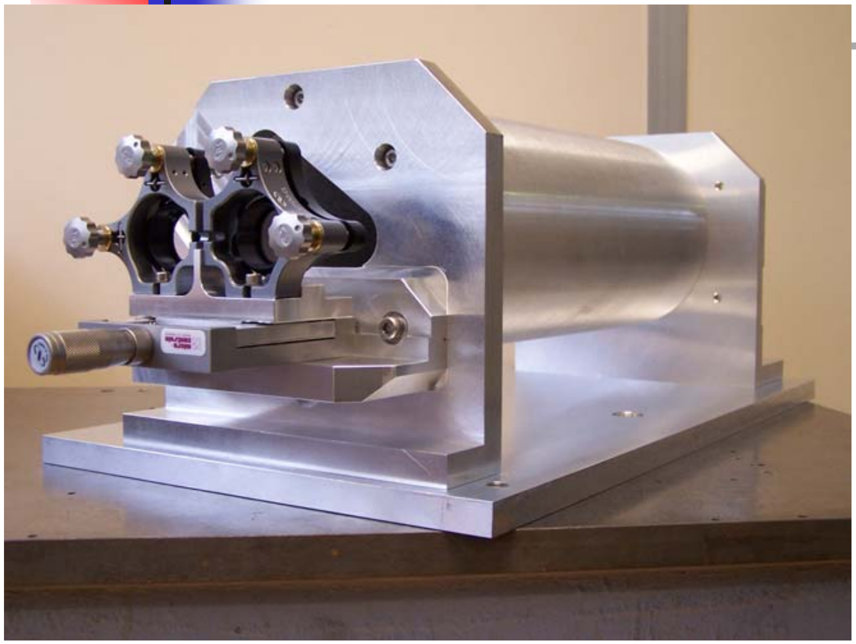
Layout of KEK-ATF Extraction Line

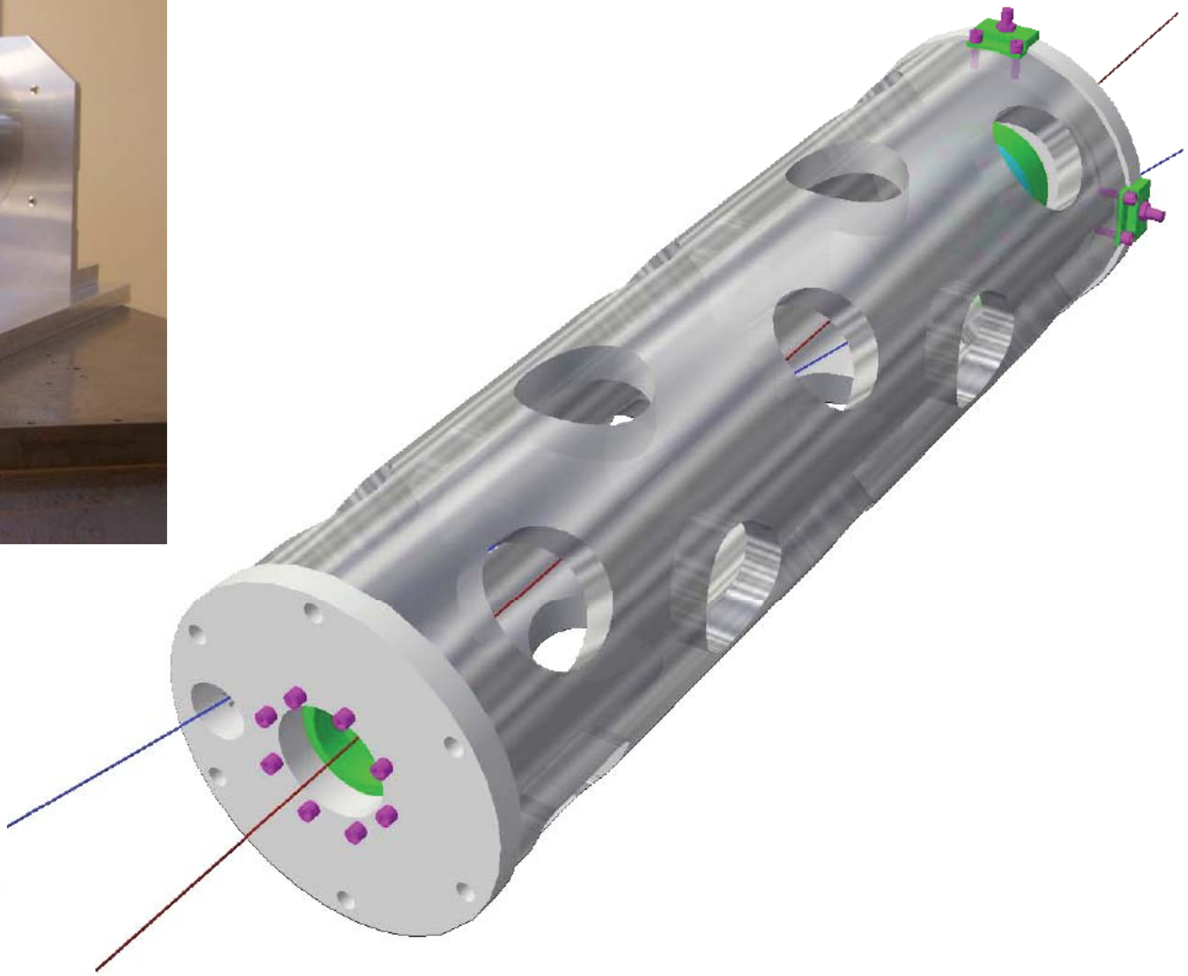
μm Feedforward (DR BPM -> EXT Line new stripline kicker)

Cavity BPM (MM1X-MM5X)
sensor cavity

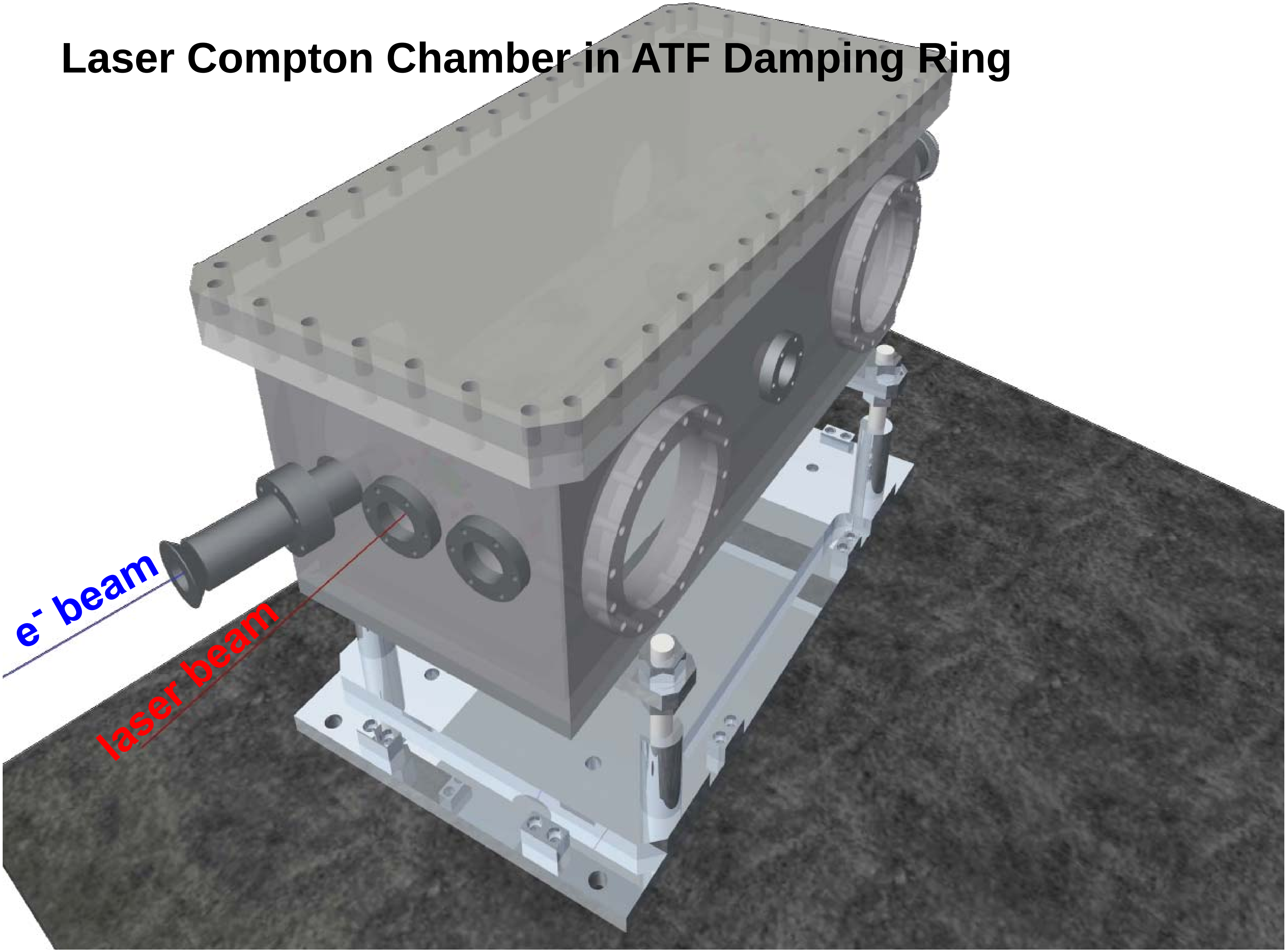
By FONT group

Optical Stacking Cavity for ILC Compton e^+ source

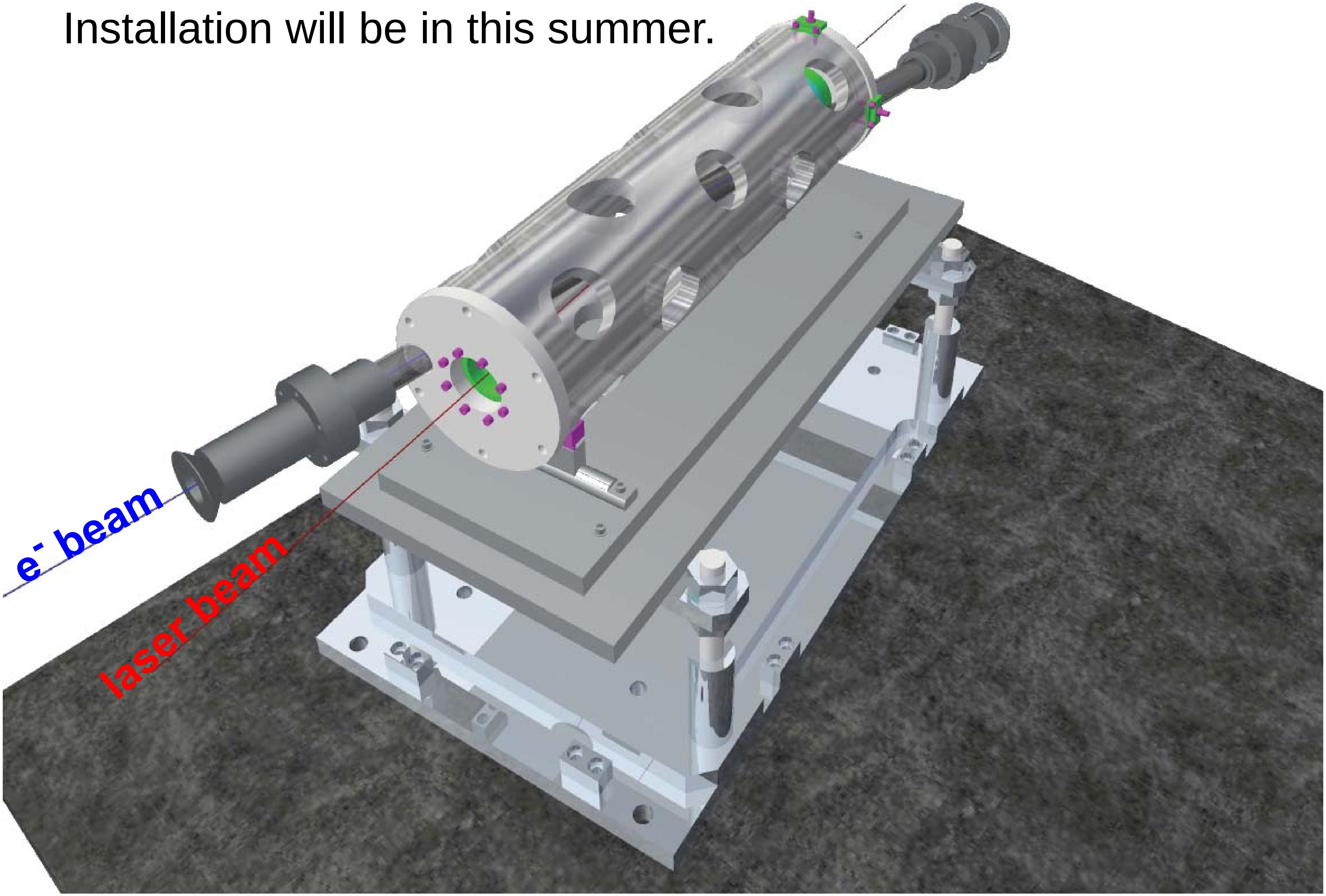




Laser Compton Chamber in ATF Damping Ring



Pulsed Laser will be enhanced by high finesse.
Installation will be in this summer.



World-wide Collaboration

PosiPol Collaboration

Collaborating Institutes:

BINP, CERN, DESY, Hiroshima, IHEP, IPN, KEK, Kyoto, LAL, NIRS, NSC-KIPT, SHI, Waseda, BNL, and ANL

Sakae Araki, Yasuo Higashi, Yousuke Honda, Masao Kuriki, Toshiyuki Okugi, Tsunehiko Omori, Takashi Taniguchi, Nobuhiro Terunuma, Junji Urakawa, X. Artru, M. Chevallier, V. Strakhovenko, Eugene Bulyak, Peter Gladkikh, Klaus Meonig, Robert Chehab, Alessandro Variola, Fabian Zomer, Alessandro Vivoli, Richard Cizeron, Frank Zimmermann, Kazuyuki Sakaue, Tachishige Hirose, Masakazu Washio, Noboru Sasao, Hirokazu Yokoyama, Masafumi Fukuda, Koichiro Hirano, Mikio Takano, Tohru Takahashi, Hirotaka Shimizu, Shuhei Miyoshi, Akira Tsunemi, Li XaioPing, Pei Guoxi, Jie Gao, V. Yakinenko, Igo Pogorelsky, Wai Gai, and Wanming Liu

CERN April 2006

http://posipol2006.web.cern.ch/Posipol2

POSIPOL 2006

POSIPOL 2007

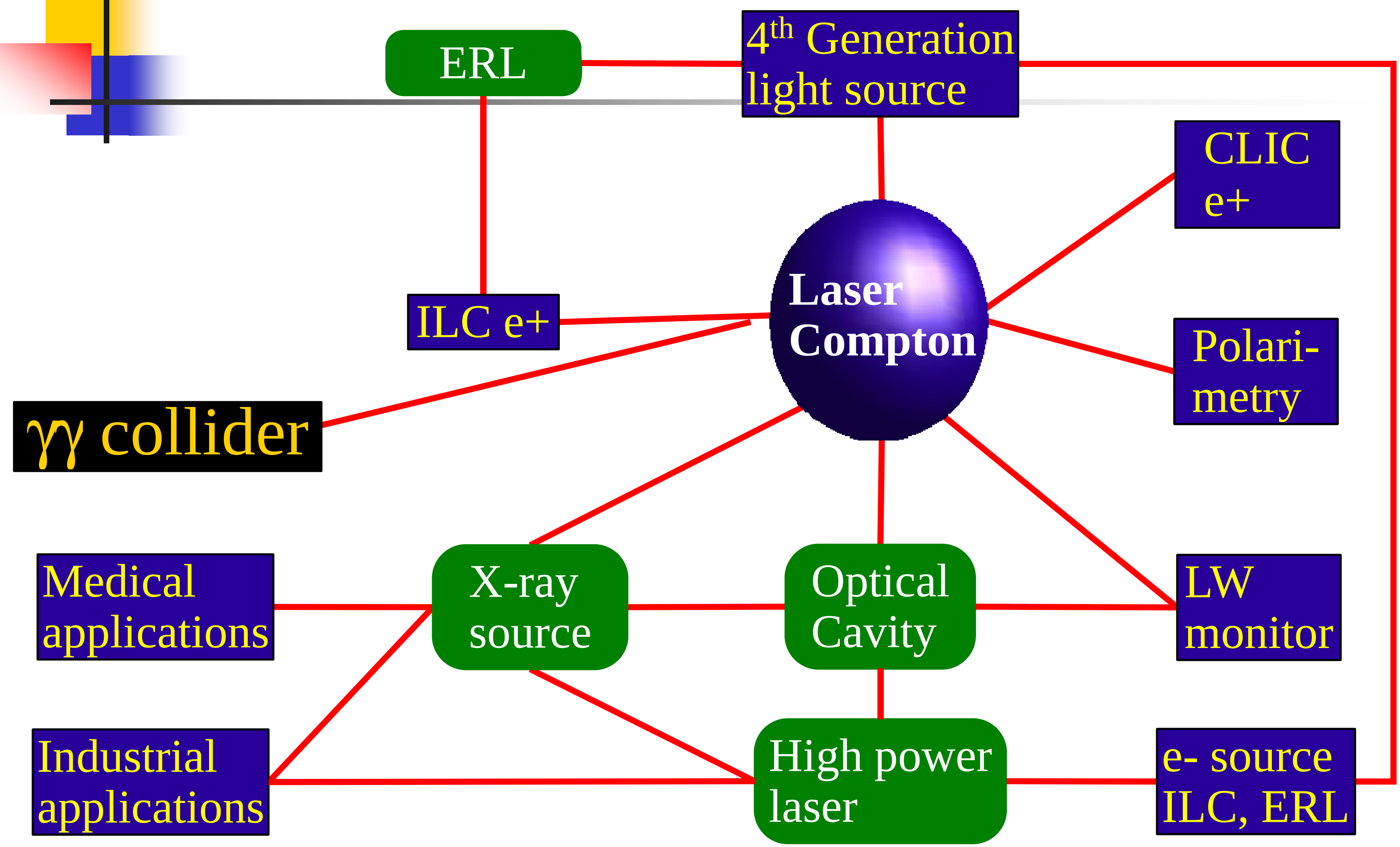
LAL-Orsay, France

23-25 May

http://events.lal.in2p3.fr/conferences/Posipo

Posipol 2008 WS, June 16-18 in Hiroshima

World-Wide-Web of Laser Compton



Comments : Schedule for ATF2

- 10/1 to 3/31 : Beam Dump, Radiation Shield System (mainly concrete blocks), Water Cooling System, Cable Tray and Air-conditioning System
- With above works and effort balance, Rough Alignment, Installation of Racks, Girders and Devices
- Be careful the limitation of the manpower and budget. Also safety.

ATF2 goals

- ATF2 goals
  - prototype ILC Final Focus system
  - develop FF tuning methods, instrumentation (laser wires, fast feedback, submicron resolution BPMs)
  - learn achieving ~35nm size & ~nm stability reliably
  - possibly test ILC Final Doublet prototype with beam
- ATF2 final goal – help to ensure collisions of nanometer beams, i.e. luminosity of ILC

Research ATF2 & synergy

- ATF2 design and operation in general
  - give experience in advanced accelerator physics and instrumentation
  - applicable to any linear collider
  - applicable to any single path beamline such as LCLS, XFEL, etc

- Advanced instrumentation & hardware developed at ATF2
  - Laser wires – applicable to x-fels, etc
  - Ultra-fast feedback – can be used e.g. for orbit stabilization in undulator of light source
  - Cavity BPM system & their calibration procedures – applicable to LCLS cavity BPM system
  - High Availability Power Supplies – applicable to sr-light and coherent x-ray sources, e.g. NSLS2 or other user facilities

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 35nm 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 technique for ILC.

ATF Control Room **2005.3.9**