ATF and Beamline Instrumentation Testing Plans

N.Terunuma

KEK

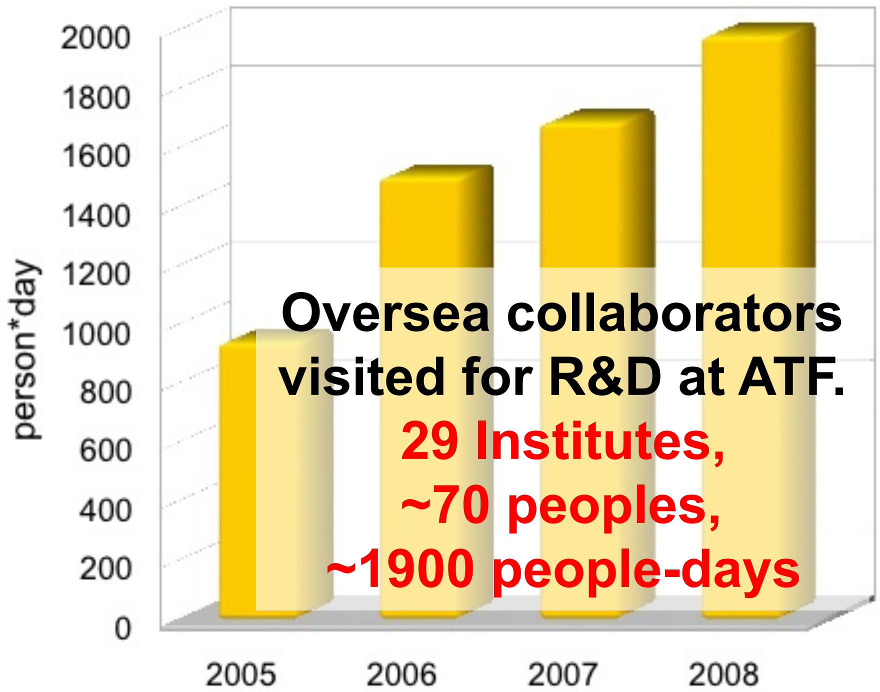
LCWA09, University of New Mexico, Albuquerque, 2009/09/30

ATF International Collaboration

CERN
DESY
LAL, Orsay
IN2P3-LAPP
Tomsk Polytechnic Univ.
INFN, Frascati
University College London
Oxford Univ.
Royal Holloway Univ.
Cockcroft Inst.
STFC, Daresbury
Univ. of Manchester

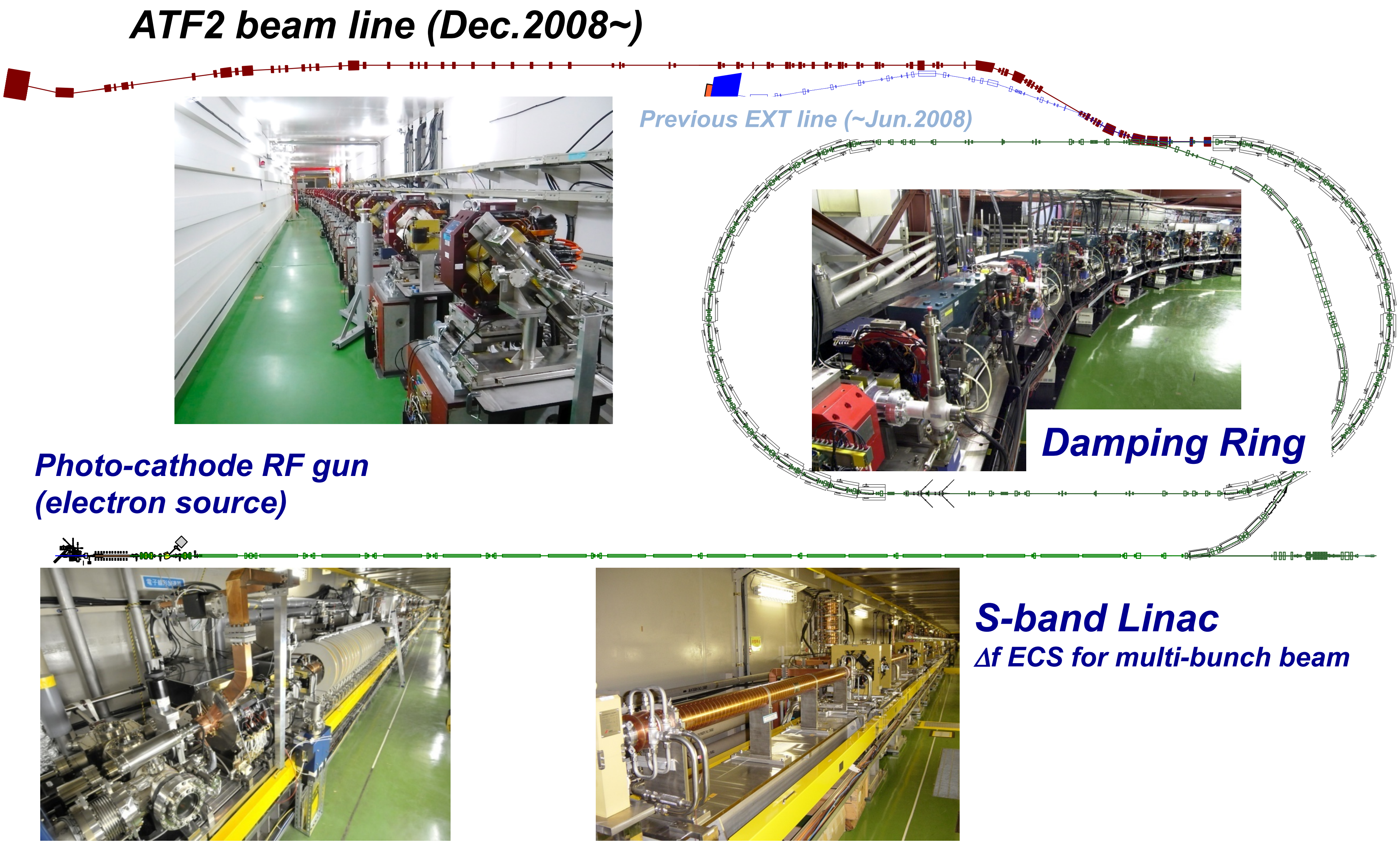
KEK
Waseda U.
Nagoya U.
Tokyo U.
Kyoto U.
Tohoku Univ.
Hiroshima U.
PAL
IHEP
KNU
RRCAT

SLAC
LBNL
FNAL
Cornell Univ.
LLNL
BNL
Notre Dome Univ.



Oversea collaborators visited for R&D at ATF.
29 Institutes,
~70 peoples,
~1900 people-days

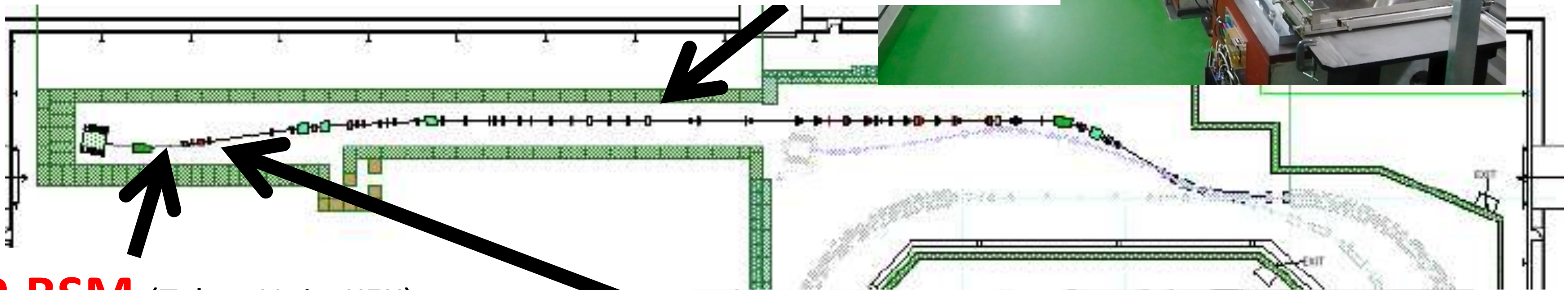
Accelerator Test Facility



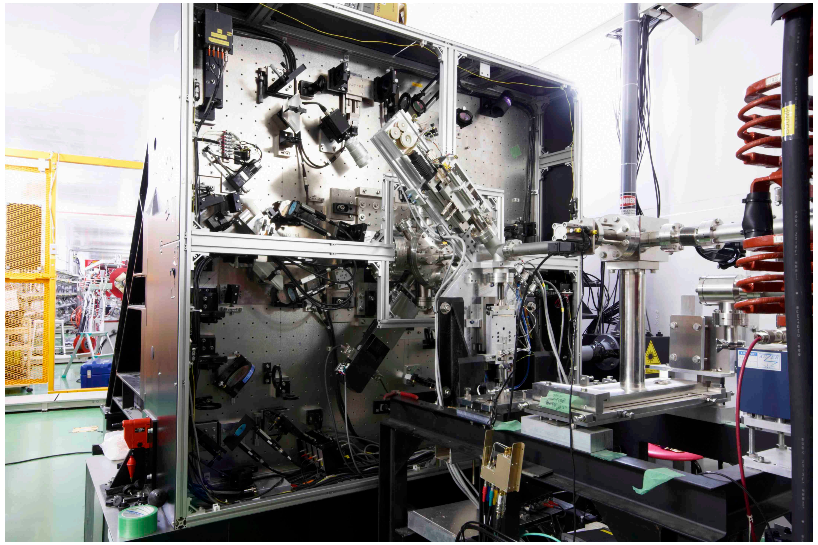
ATF2 Beamline

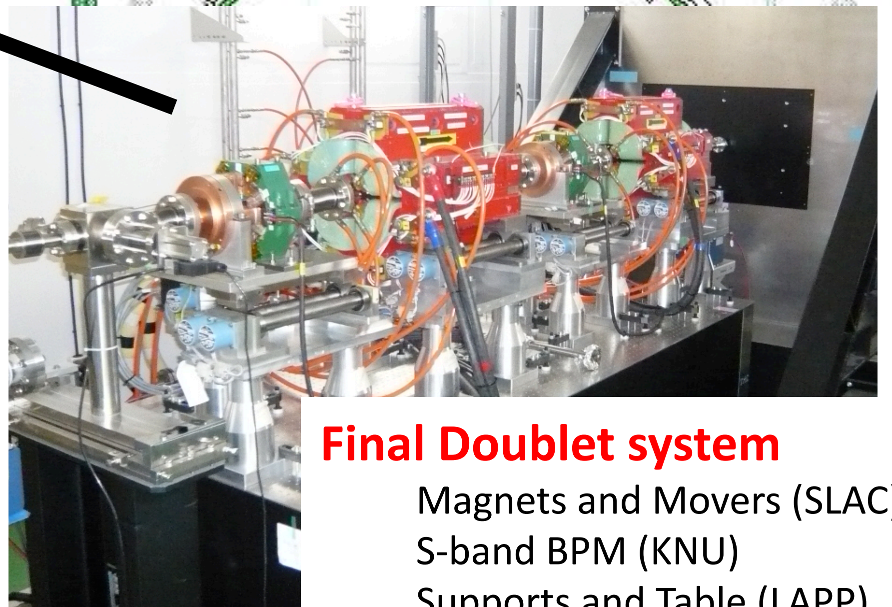
Final Focus beamline

Magnets and Movers (IHEP, SLAC, KEK)
C-band BPM (PAL, SLAC, KEK)
Support Table (KEK)



IP-BSM (Tokyo Univ, KEK)





Final Doublet system

Magnets and Movers (SLAC)
S-band BPM (KNU)
Supports and Table (LAPP)

ATF/ATF2 R&D Plan

ILC R&D plan for TD phase, June 2009

Table 3-3: TD Phase Beam Test Facilities Deliverables and Schedule.

Test Facility	Deliverable	Date
Optics and stabilisation demonstrations:		
ATF	Generation of 2 pm-rad low emittance beam	2010
ATF-2	Demonstration of compact Final Focus optics (design demagnification, resulting in a nominal 35 nm beam size at focal point).	2010
	Demonstration of prototype SC and PM final doublet magnets	2012
	Stabilisation of 35 nm beam over various time scales.	2012
Linac high-gradient operation and system demonstrations:		
TTF/FLASH & STF & ILCTA-NML	Full 9 mA, 1 GeV, high-repetition rate operation (TTF / FLASH)	2009
	Cavity-string test within one cryomodule (S1 and S1-global)	2010
	Cryomodule-string test with one linac/RF Unit with beam (S2)	2012

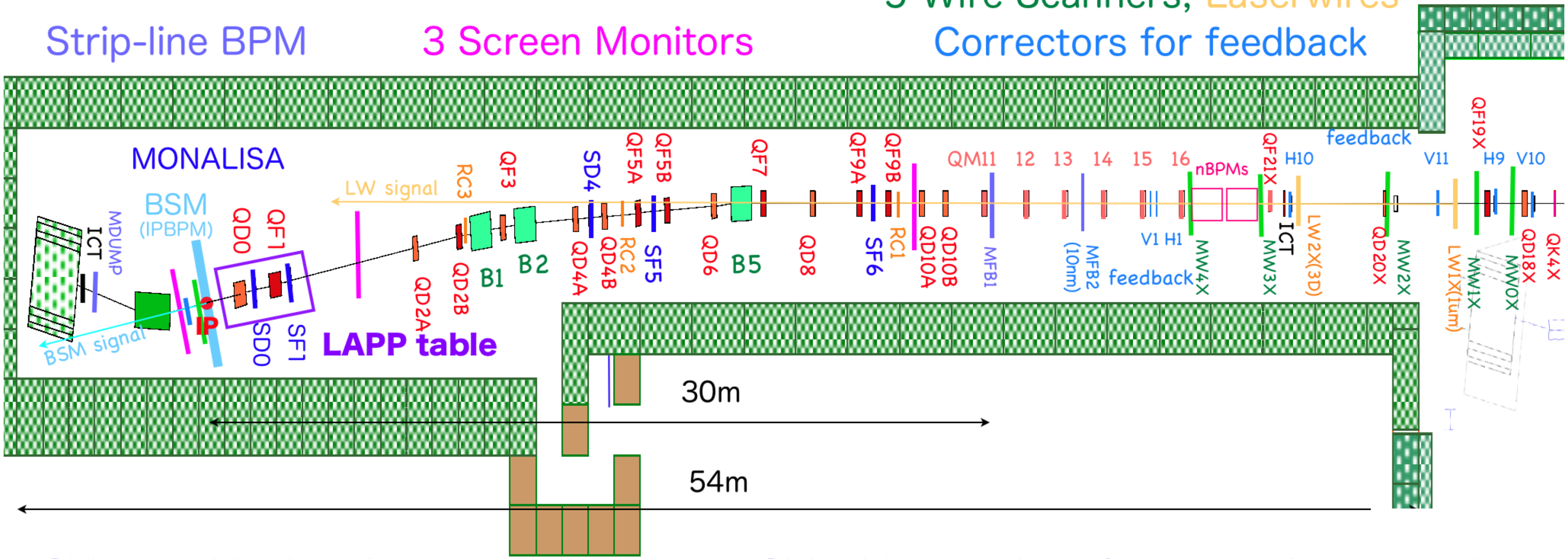
Hardware system at ATF2

22 **Q**uadrupoles, 5 **S**extupoles, 3 **B**ends in downstream of QM16
(IHEP, China, MOPP014) (SLAC) (SLAC, IHEP)

All Q- and S-magnets have cavity-type beam position monitors(QBPM, 100nm).
(PAL, Korea)

5 Wire Scanners, Laserwires

Strip-line BPM 3 Screen Monitors Correctors for feedback



Shintake Monitor (beam size monitor, BSM with laser interferometer):Tokyo univ.

MONALISA (nanometer alignment monitor with laser interferometer):Oxford univ.

Laserwire (beam size monitor with laser beam for 1 μm beam size, 3 axies):RHUL

IP intra-train feedback system with latency of less than 150ns (FONT):Oxford univ.

Magnet movers for Beam Based Alignment (BBA):SLAC - MOPP039

High Available Power Supply (HA-PS) system for magnets:SLAC

T.Tauchi, EPAC08

Overview

There are a lot of R&D programs at ATF/ATF2 related for DR and BDS.
Report on this meeting is focused on the R&Ds for ATF2.

(1) Beam position Monitors
- Cavity BPMs

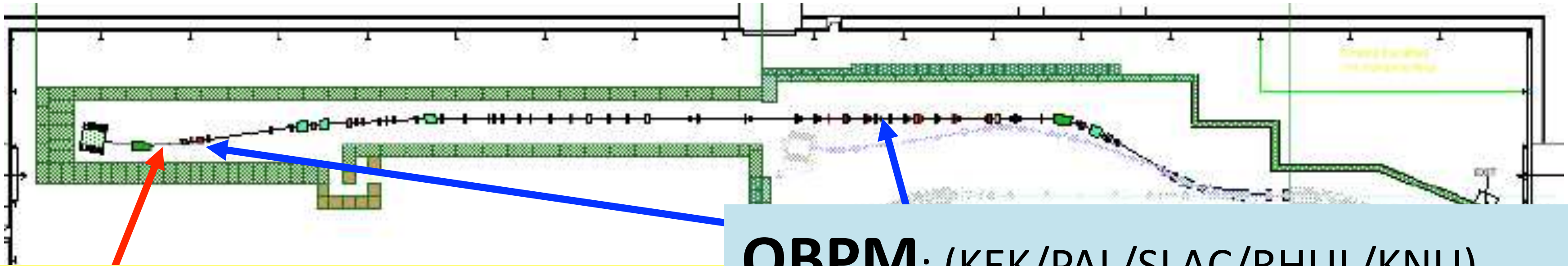
(2) Beam control/feedback
- Fast Kicker
- FONT

(3) Beam Size Monitors
- Pulsed Laser Wire
- IP-BSM (Shintake monitor)

(4) Relative motion Monitors
- Monalisa at ATF2
- Straightness monitor at ATF2

- Beam Position Monitors -

ATF2 beamline with Cavity BPM



IP-BPM: (KEK/KNU/RHUL)

Target resolution: 2nm

Achieved resolution: 8.7nm

Planning to install in 2010

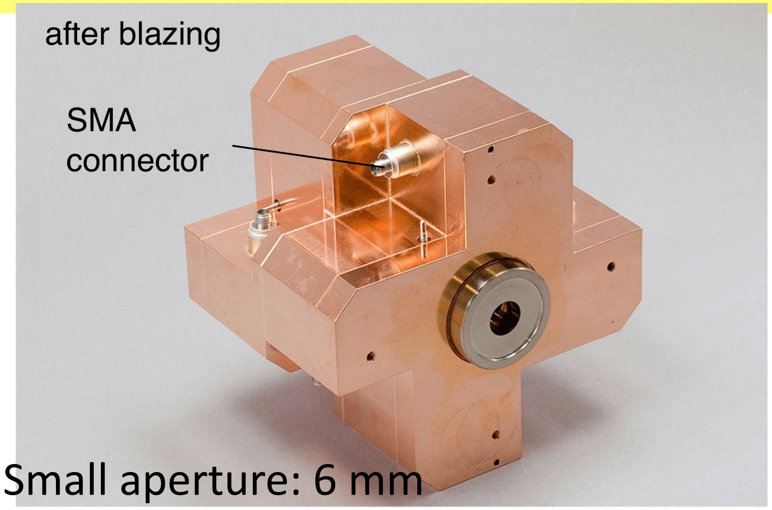
QBPM: (KEK/PAL/SLAC/RHUL/KNU)

Target resolution: 100nm

Achieved resolution: 17nm

Total 38 units

Installed: C-band 34、S-band 4



Small aperture: 6 mm

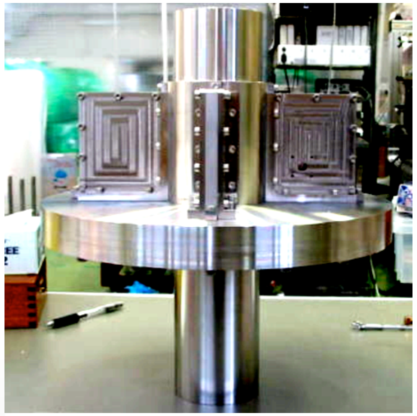
Aperture: C-band 20 mm, S-band 40 mm

Beam test of ILC Main Linac Cold-BPM

Sunyoung Ryu (PNU), T. Hino (Tohokugakuin), H. Hayano (KEK)

Requirements:

- High resolution (< 1μm for single pass).
- Good fiducialization capability with respect to Q-magnet center.
  (cylindrical outer, good common-mode rejection required)
- Big beam-pipe aperture (78mm diameter).
- HPR washable and cleanness required.
- Need to withstand wide thermal excursion without vacuum leak.
- Bunch-to-bunch signal acquisition required (low QL).
- No interference with acc. cavity HOM(1.6-1.9GHz and > 2.3GHz).



SUS cold model

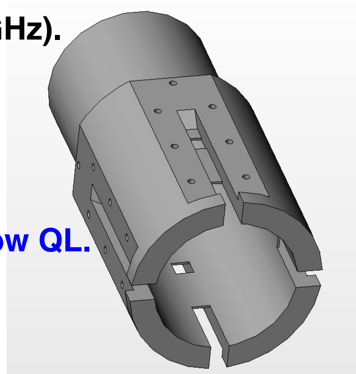
Our design selection:

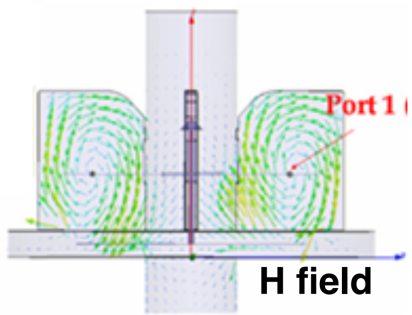
Cavity BPM with 4 slots coupled.

→ high resolution, good fiducialization, withstand to thermal excursion.

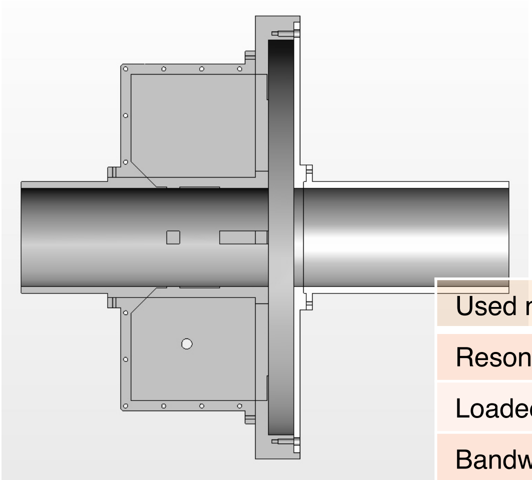
Use 2nd higher mode → match to big beam pipe, easy to get low QL.

4 slots open to beam pipe →HPR washable.



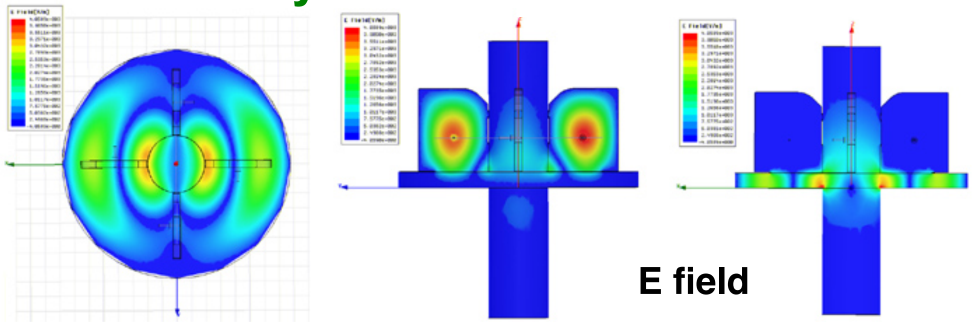


H field



Used mode	TM120
Resonance freq.	2.04GHz
Loaded Q	260
Bandwidth	8MHz

Calculation by HFSS



E field

Status of the Cavity BPMs at ATF2

QBPM:

C-band: distributed along the ATF2 beamline, **commissioned**

S-band: at the final doublet, installed, will start the commissioning in October 2009.

IP-BPM:

It will be installed in 2010.

- used for 35 nm beam size measurement to evaluate the beam position jitter.
- used for nm level beam position stabilization

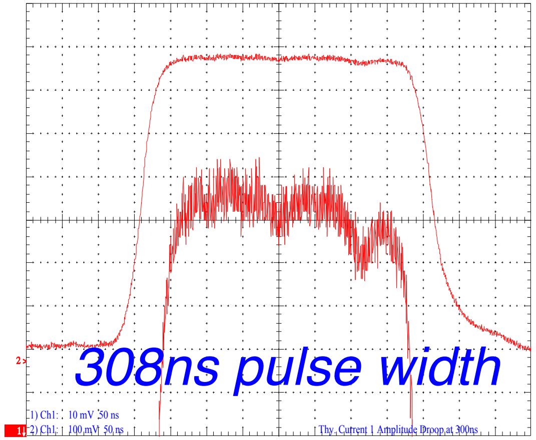
Cold-ML-BPM:

Beam test will be continued at ATF linac or ATF2 test section.

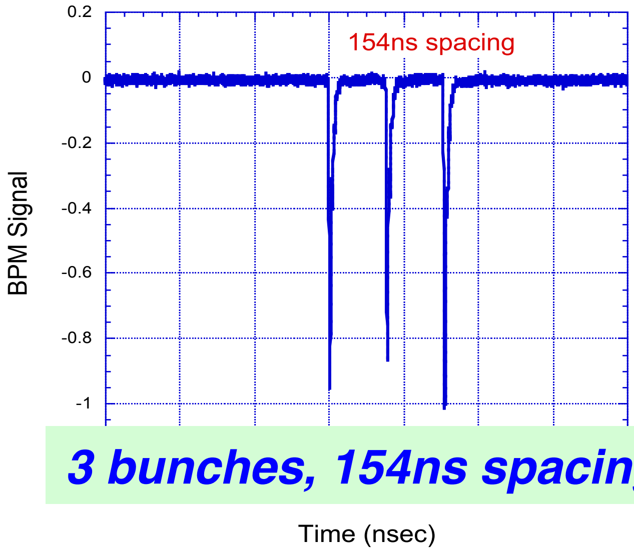
- Beam Control/feedback -

Upgrade Plan of Multi-bunch beam in ATF2

Present ATF kicker
(Pulse magnet kicker system)

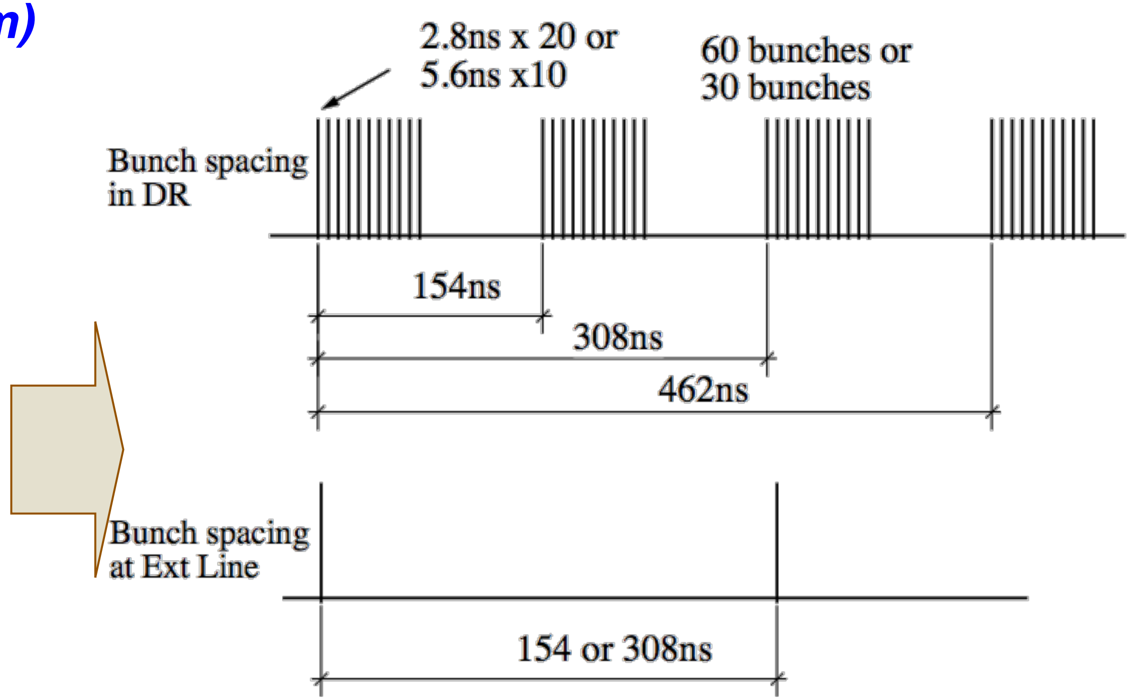


(Single bunch) x 3 Train Extraction



3 bunches, 154ns spacing

Bunch structure at ATF2 by Fast kicker



Multi-bunch in ATF2 by fast kicker

30 bunches with 308 ns spacing

60 bunches with 154 ns spacing

- Demonstrate the beam extraction
- Check the reliability

Fast kicker R&D

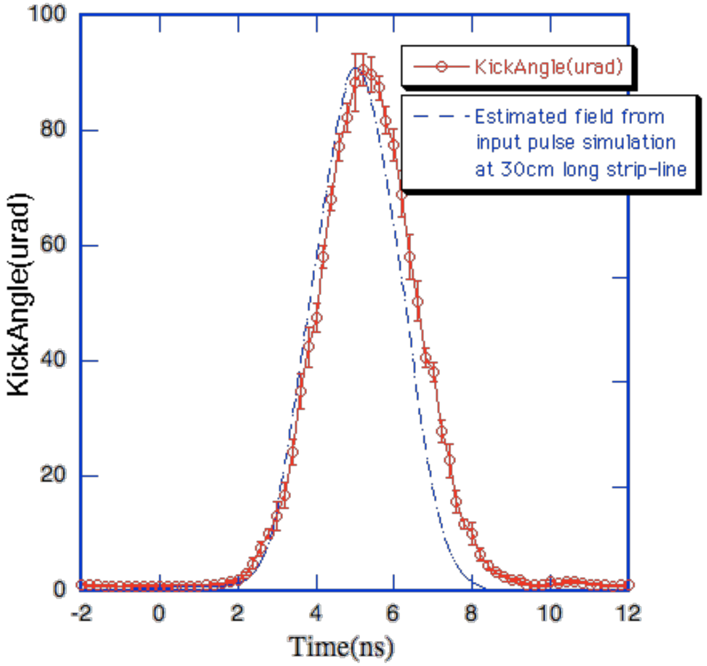
(KEK,DESY,SLAC,LLNL)

Key technology for ILC damping ring

2005 - 2008

Demonstration of very fast pulse kicker by using the electron beam in ATF damping ring.

R&D with several pulsers



2007～

Design of the beam extraction system by fast kicker

2009～

Trial of beam extraction

Multi-bunch in ATF2

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

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

R&D of Beam Extraction by Fast Kicker

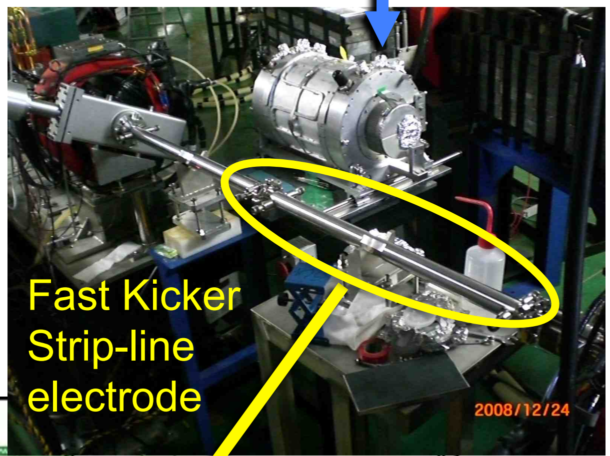
Switch the conventional pulse magnet (5 mrad) to a combination of
Fast kicker + aux. septum + pulse bump orbit

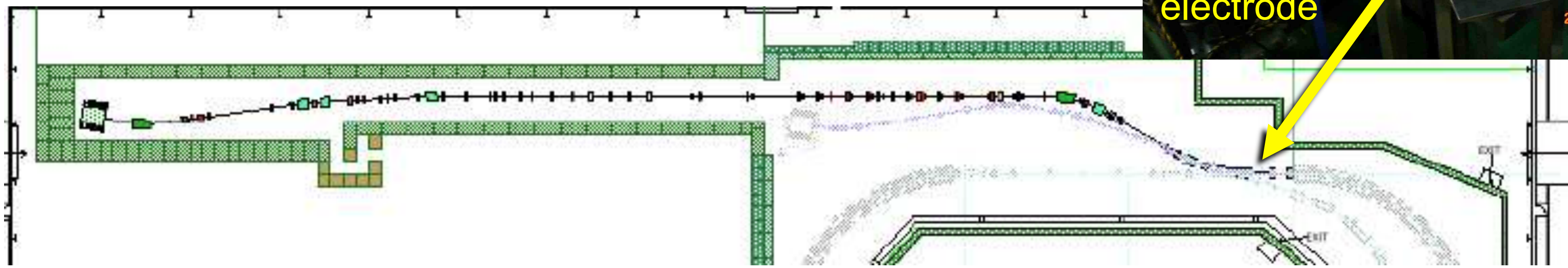
In the previous test runs, we confirmed followings.

- A beam from Linac was stored in DR without any beam loss.
- Pulse bump system and the auxiliary septum works well.
- The fast HV pulser worked well without any trouble.

1) aux. septum can be shorten and the distance to a circulating beam can be increased.
2) The strip-line electrode should be modified.

Conventional
Pulse magnet





Next beam test is scheduled,

2009 Oct. 2weeks(10/19~, 10/26~)

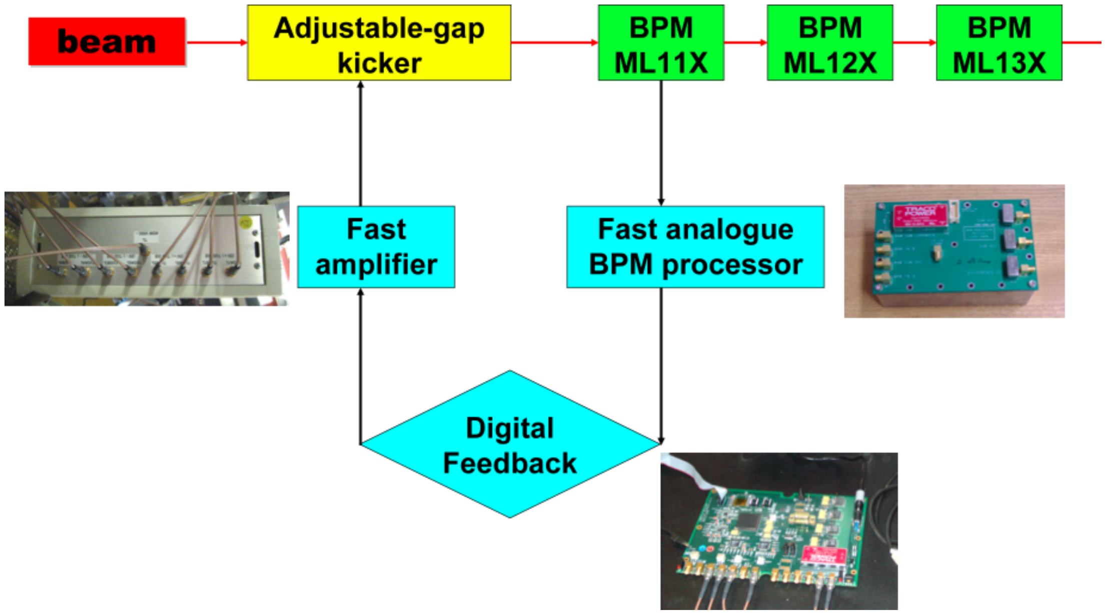
2010 Jan. 1week(1/18~).

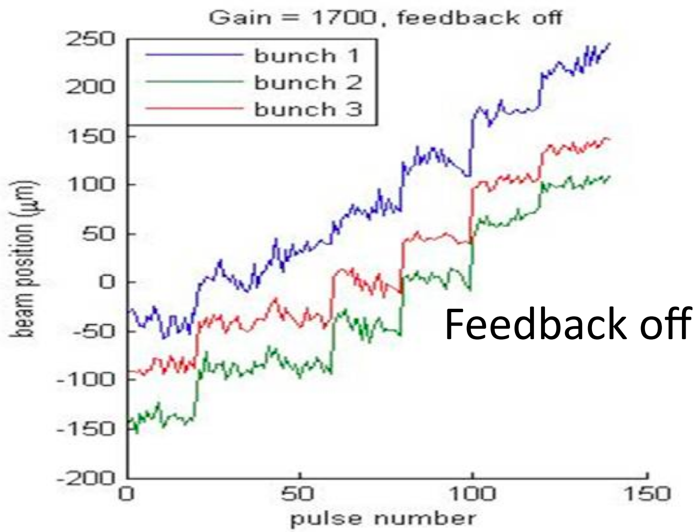
Improvements for next beam test,

1. *Re-fabricate the strip-line electrode(20%?)*
2. *Using 4ns pulser x 4 (25%)*
3. *Strip-line gap 12mm->9mm(30%)*
4. *Length of the aux. septum 60cm->30cm*

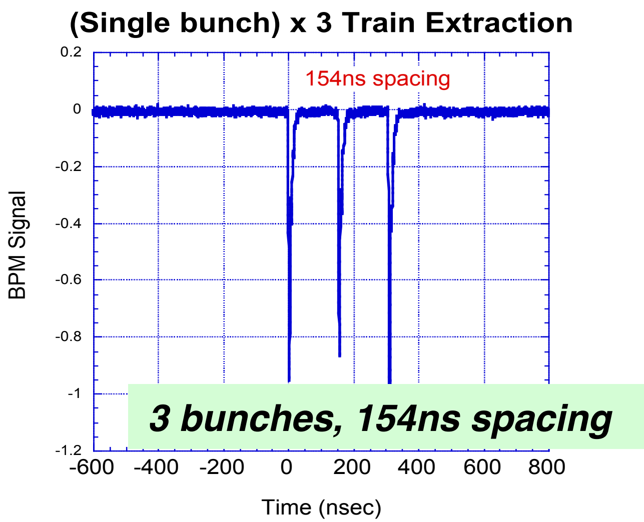
FONT4 –Digital feedback R&D at ATF-

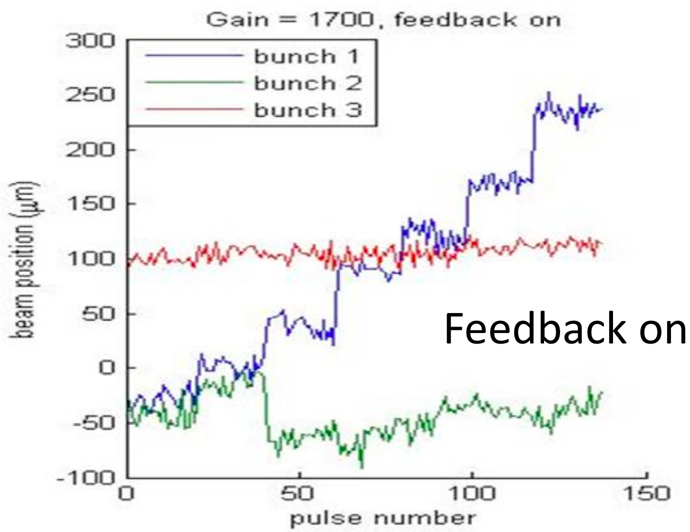
Oxford, Daresbury, QMUL, SLAC, KEK, DESY, CERN





Beam position vs pulse number

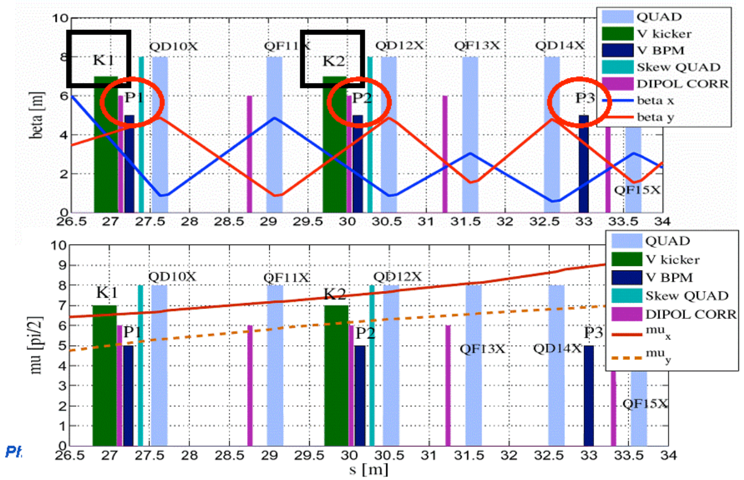


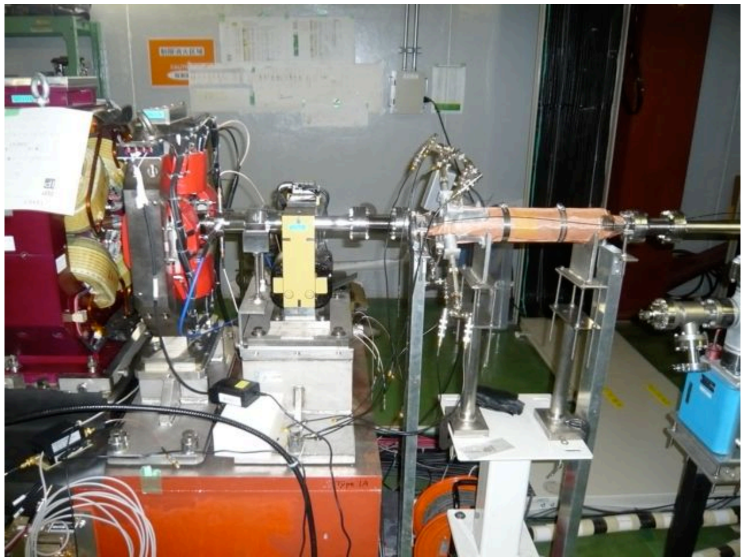


Application of FONT to stabilize the ATF2 Beam

Layout of FB/FF components at ATF2

(FONT group – Resta Lopez)

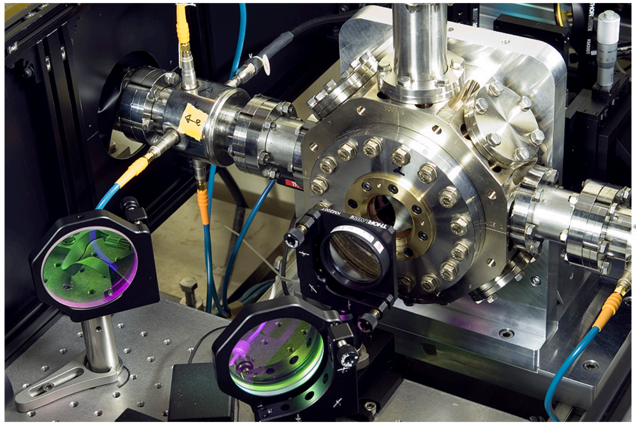


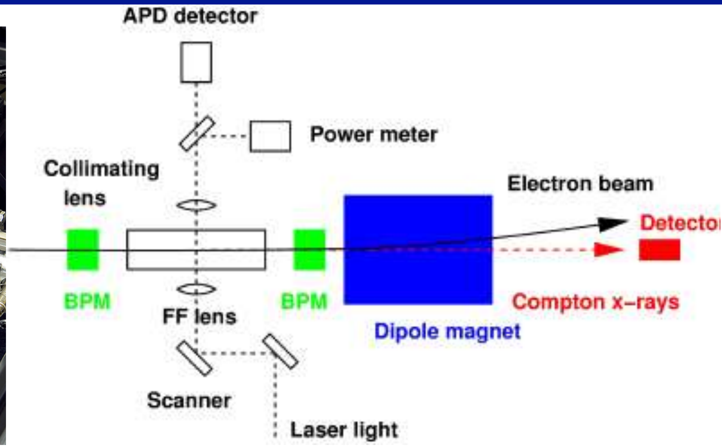


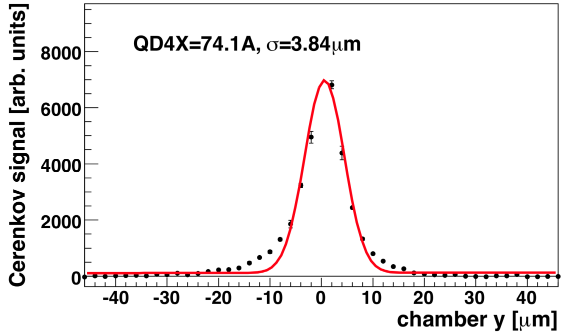
- Key system for stabilization of ATF2 beam.
- Dedicated system with two kickers and three bpms.
- First fully-digitised FONT feedback and DAQ system
- Installation and initial hardware checkout were performed in Spring 2009.
- Movers for FONT bpms will be installed in Oct. 2009 (next week).
- New digital board FONT5 will be tested.

- Beam Size Monitors -

Pulsed Laser Wire R&D (RHUL, Oxford, KEK)







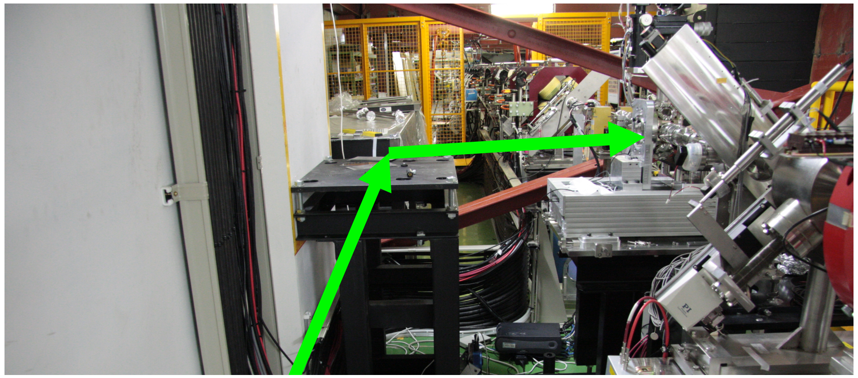
ILC design requirement:

< 1 um laser wire scanner

2008/May

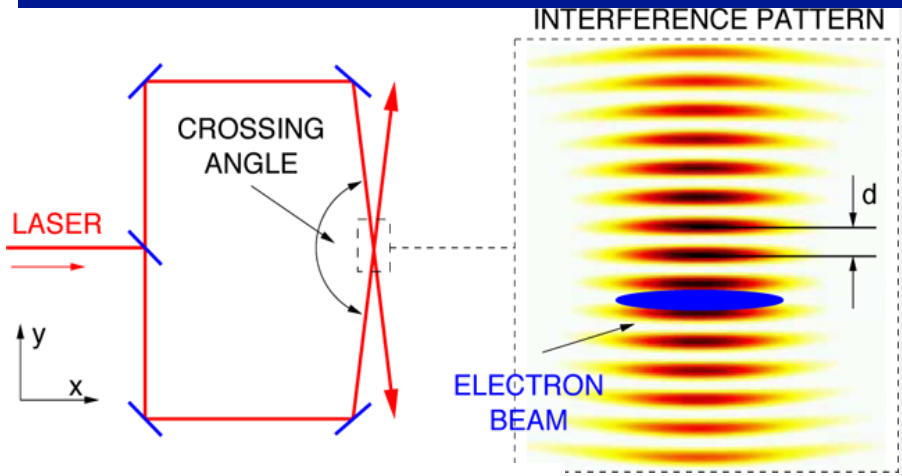
σ~3.8um was achieved.

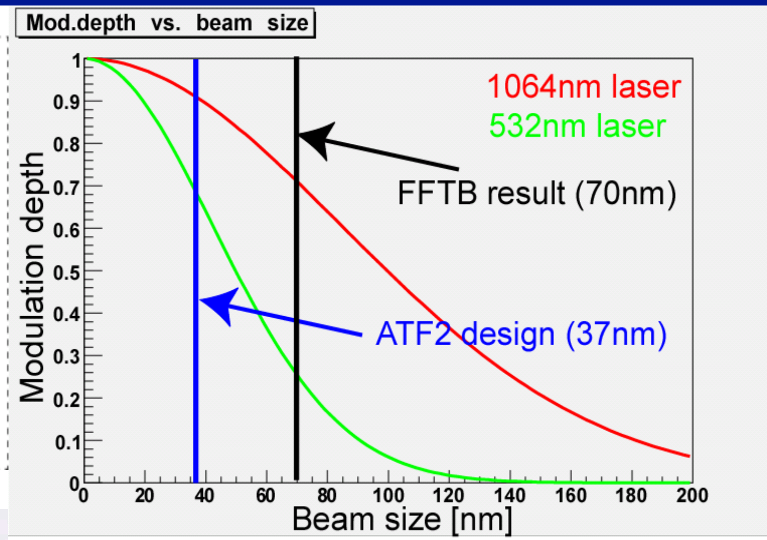
Realize the 1 um beam size scanning in FY2008, by implementing improvements in the electron beam optics and improved laser diagnostics.

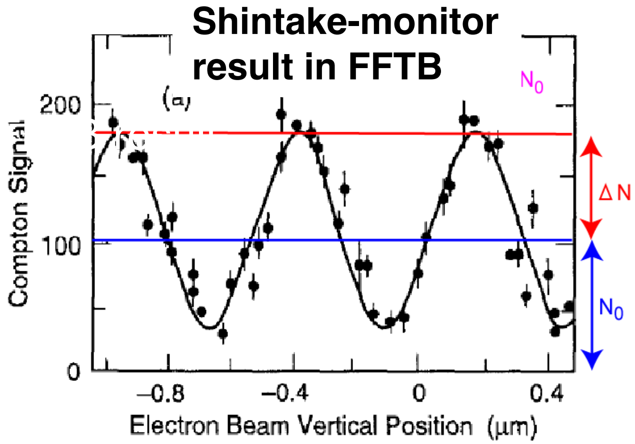


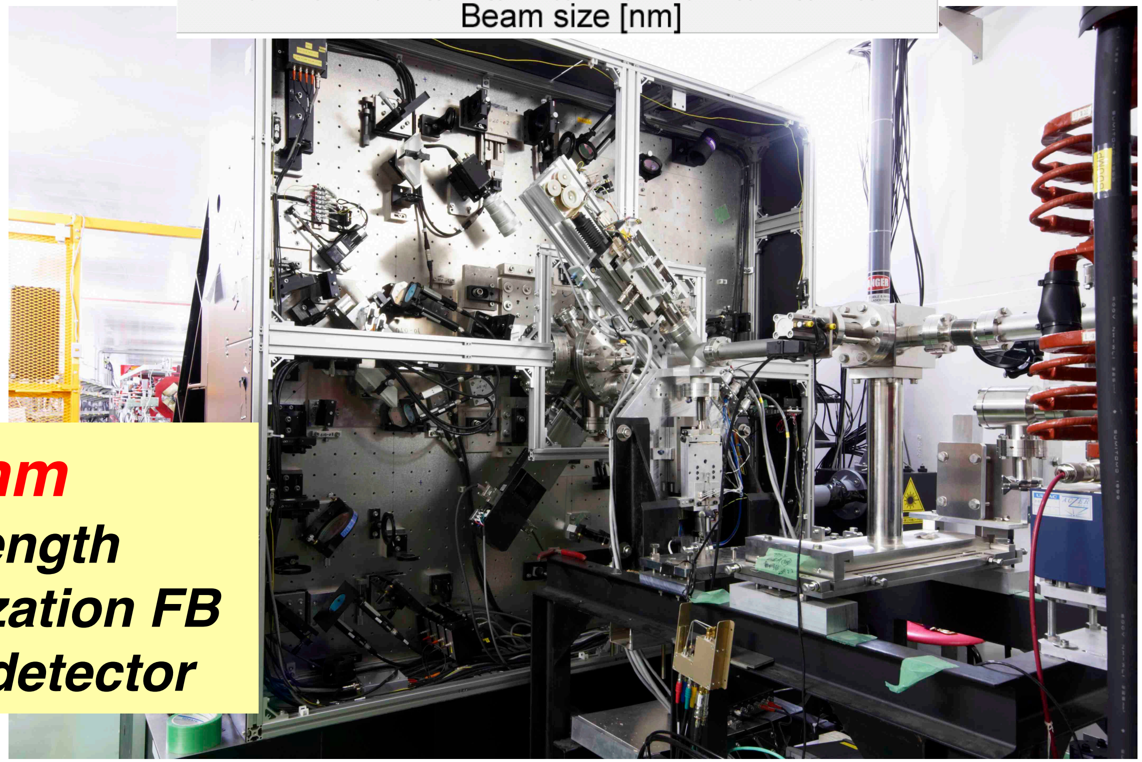
- **Under the construction at new location in ATF2**
- **Commissioning will be started on December 2009.**

Beam size monitor for ATF2-IP (Tokyo Univ., KEK)









FFTB ~70nm -> ATF2 35nm

modification : Laser wavelength

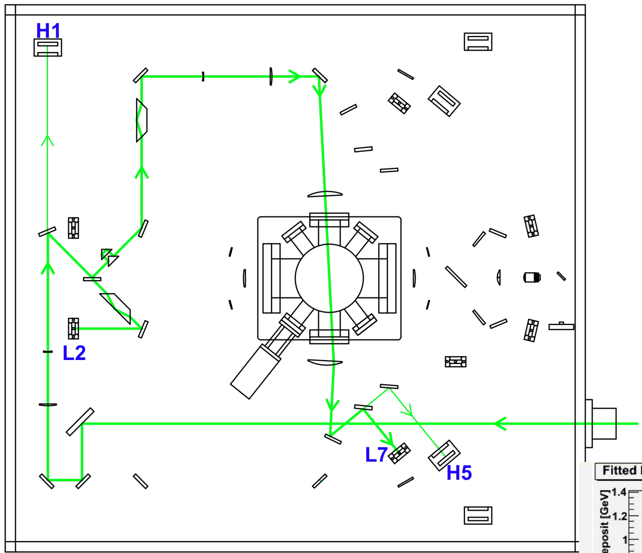
fringe stabilization FB

new gamma detector

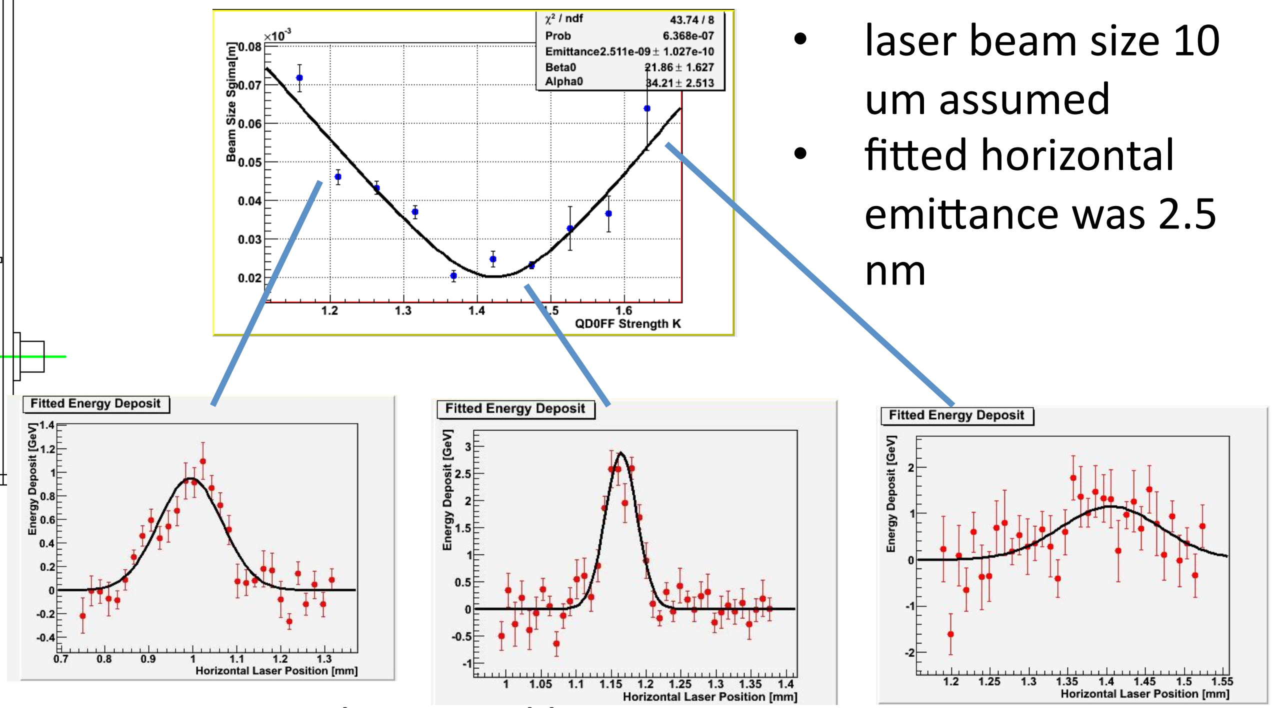
Laser wire mode

-**Scanner for horizontal beam size –**

-**Used for system check in the first ATF2 run period (~May 2009)**



Example of Q-Scan by Laser Wire mode



- laser beam size 10 um assumed
- fitted horizontal emittance was 2.5 nm

horizontal beam size at MW1IP was 20 um

=> almost consistent

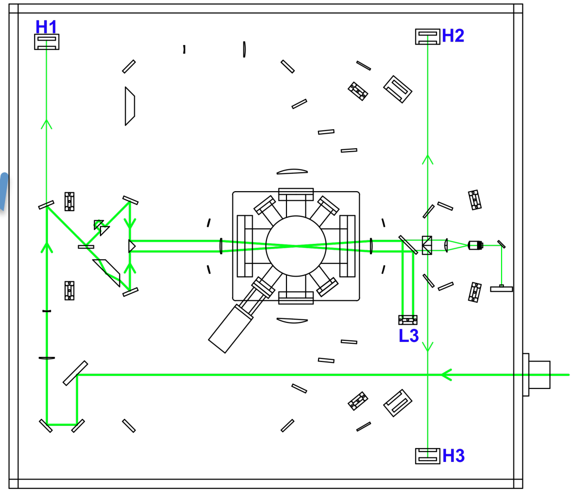
Interference mode

Setup for larger beam size.

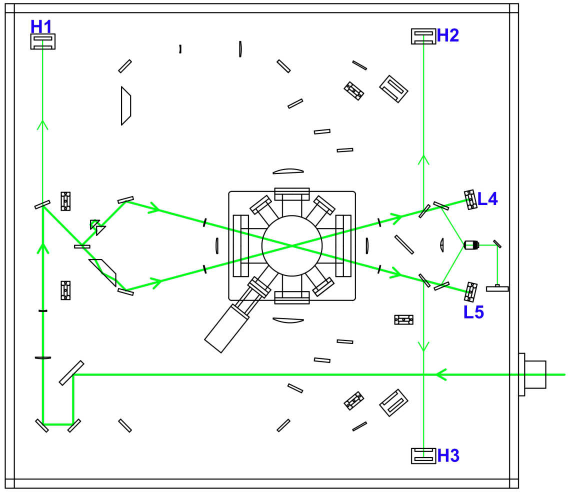
It will be commissioned in next runs (Nov 2009~).

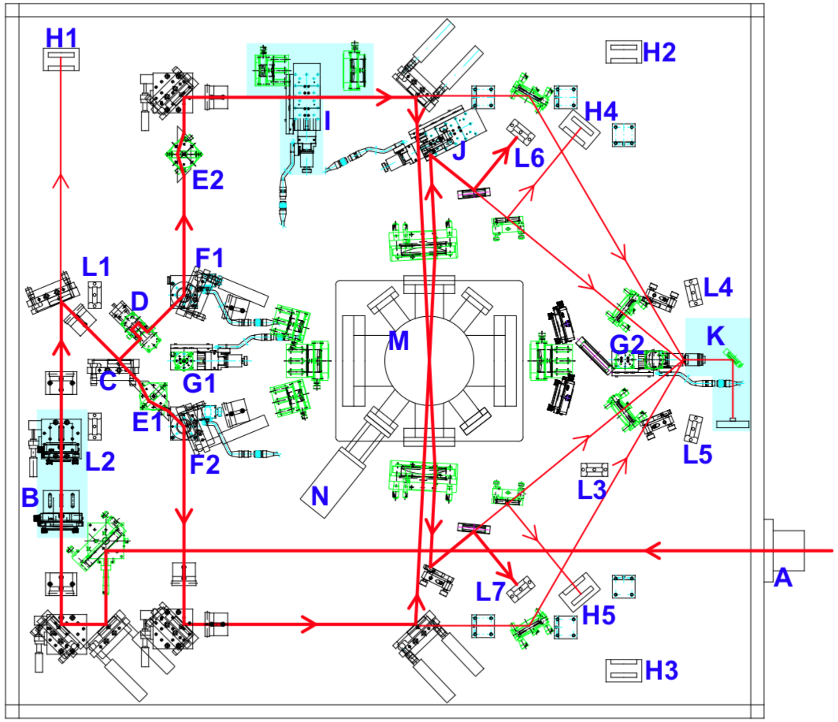
2 degrees;
1400~? nm

8 degrees;
360~1400 nm



30 degrees;
100~360 nm





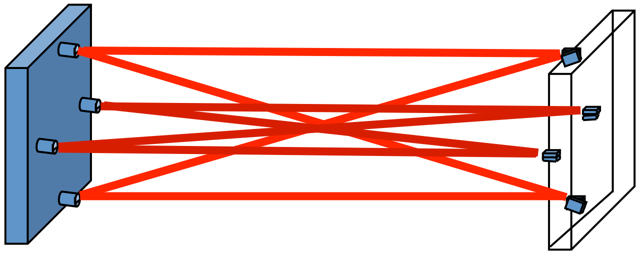
Setup for 35 nm measurement

174 degrees;
25~100 nm

- Monitors for Relative Motion -

MONALISA at ATF2 (Oxford)

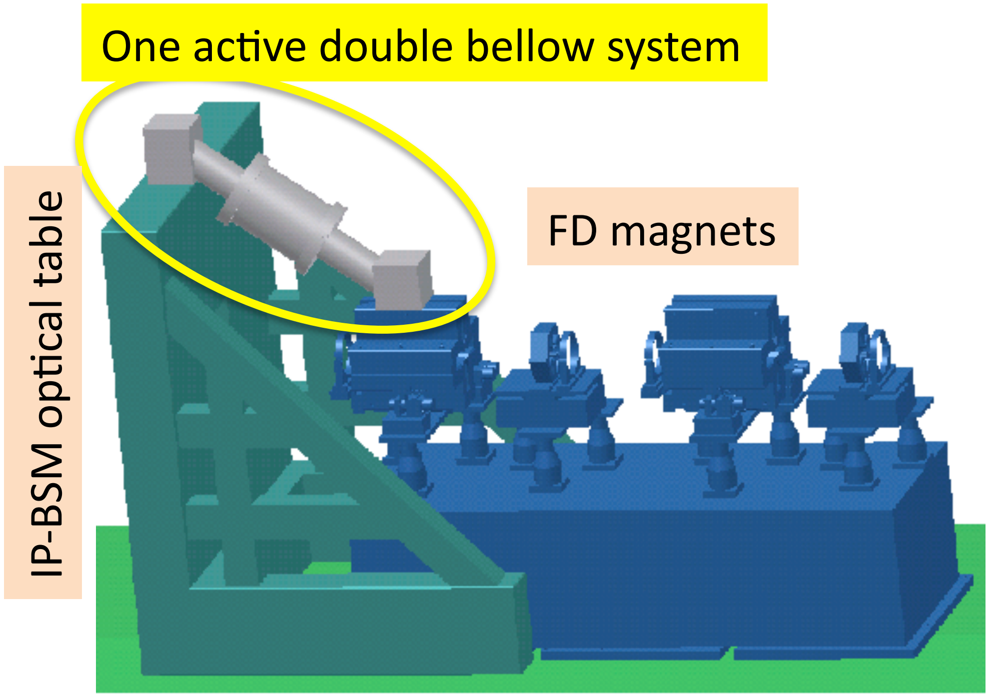
- **Monitor the relative motion between final focus quadrupole and the IP-BSM (Shintake Monitor).**
  - This avoids a false increase of the measured beam spot caused by motion of the Shintake monitor.



- Network of distance metres

- Vacuum vessel of MONALISA was temporary installed to check the consistency with the FD+IP system, in July 2009.

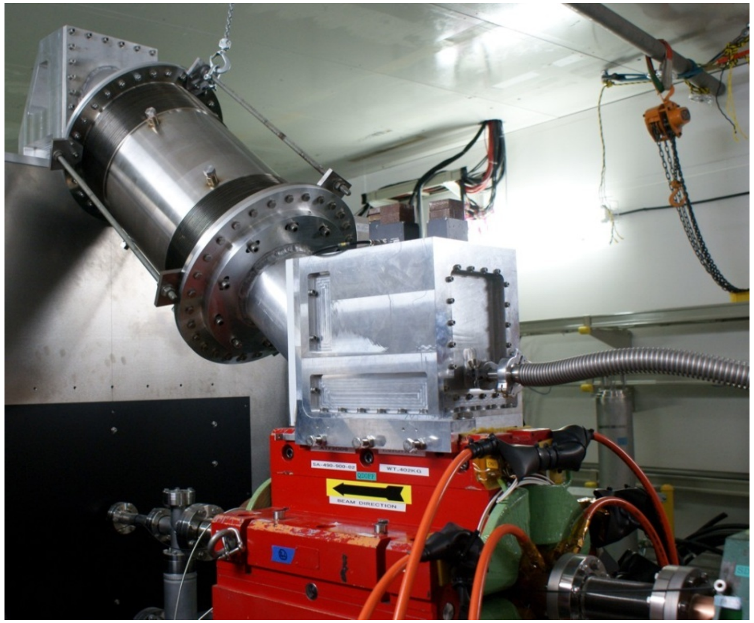
- Re-installation with distance meters is planned in the Spring of 2010.



Impact of Monalisa on vibrations

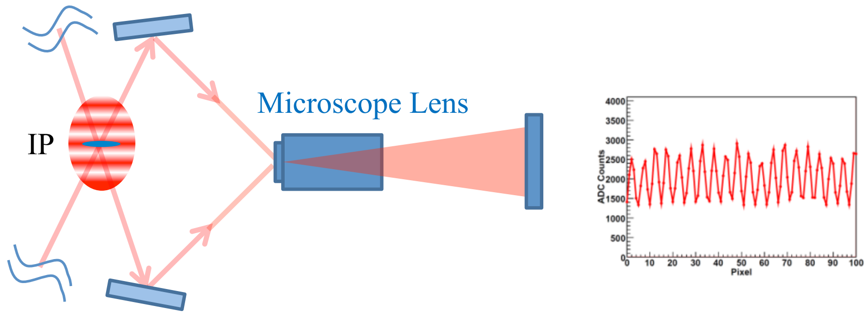
✓ With GM/flowing cooling water, relative motion of SM to QD0:

	Tolerance	Without Monalisa	With Monalisa (Press/No press)
Vertical	7 nm	5.0nm	5.7nm/5.8nm
Perpendicular to beam	~ 500 nm	16.7nm	16.7nm
Parallel to the beam	~ 10,000 nm	17.2nm	17.2nm



Vibration measurements between Shintake and QD0

Phase Stability Measurement of IP-BSM

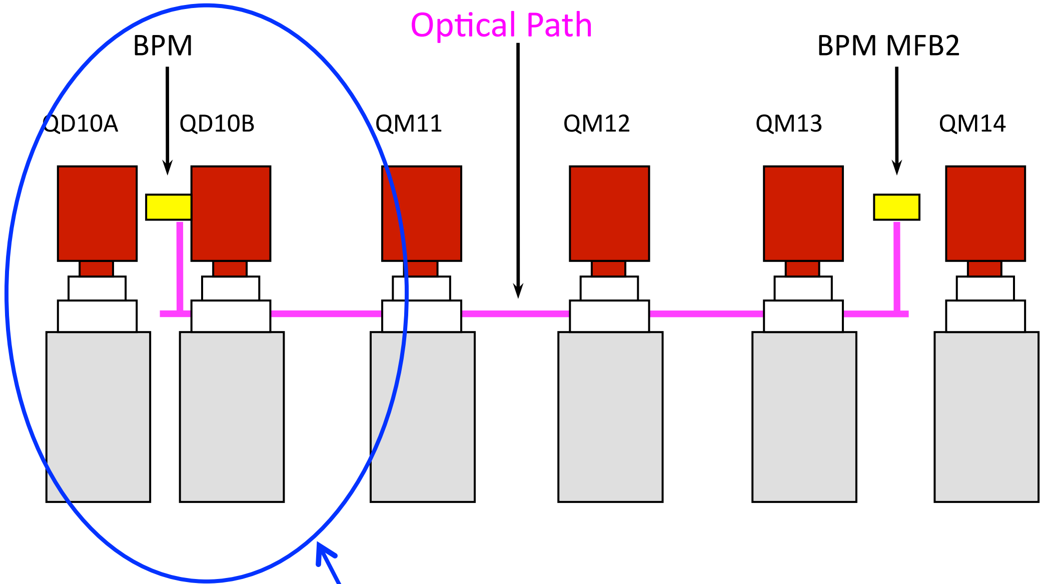


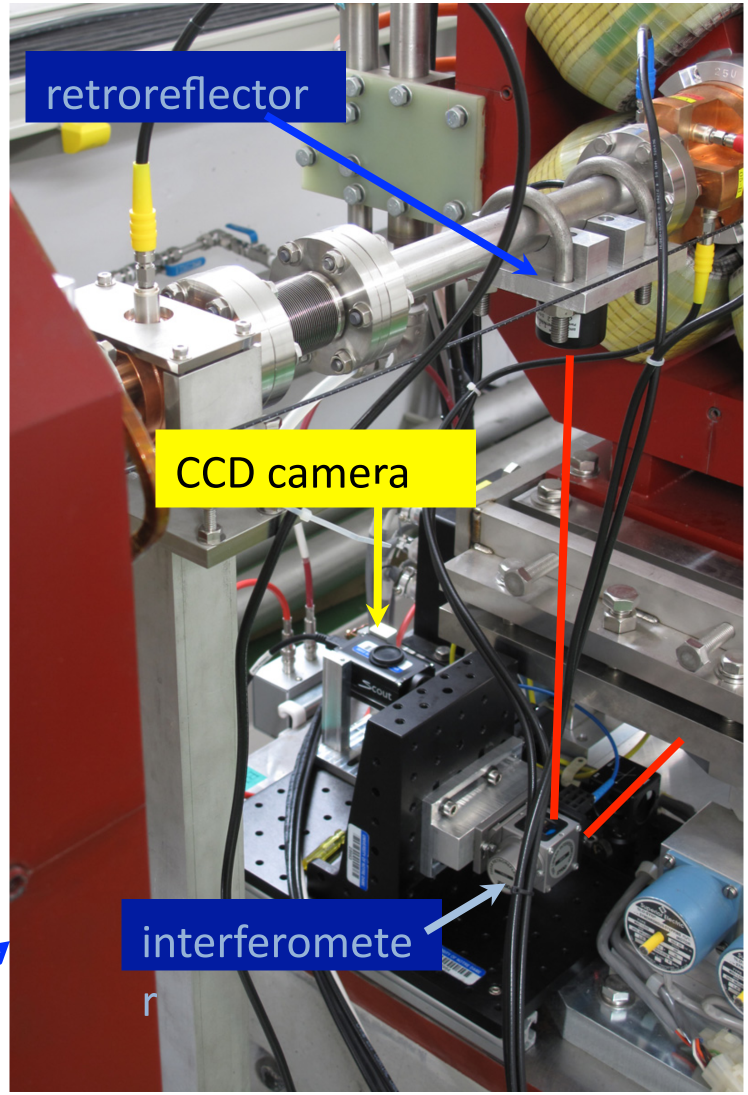
Results give the fringe position stability,
6 nm without MONALISA,
7 nm with MONALISA.

Application of the Straightness monitor at ATF2 (Notre Dome Univ.)

Full System (Later, Oct. 2009):

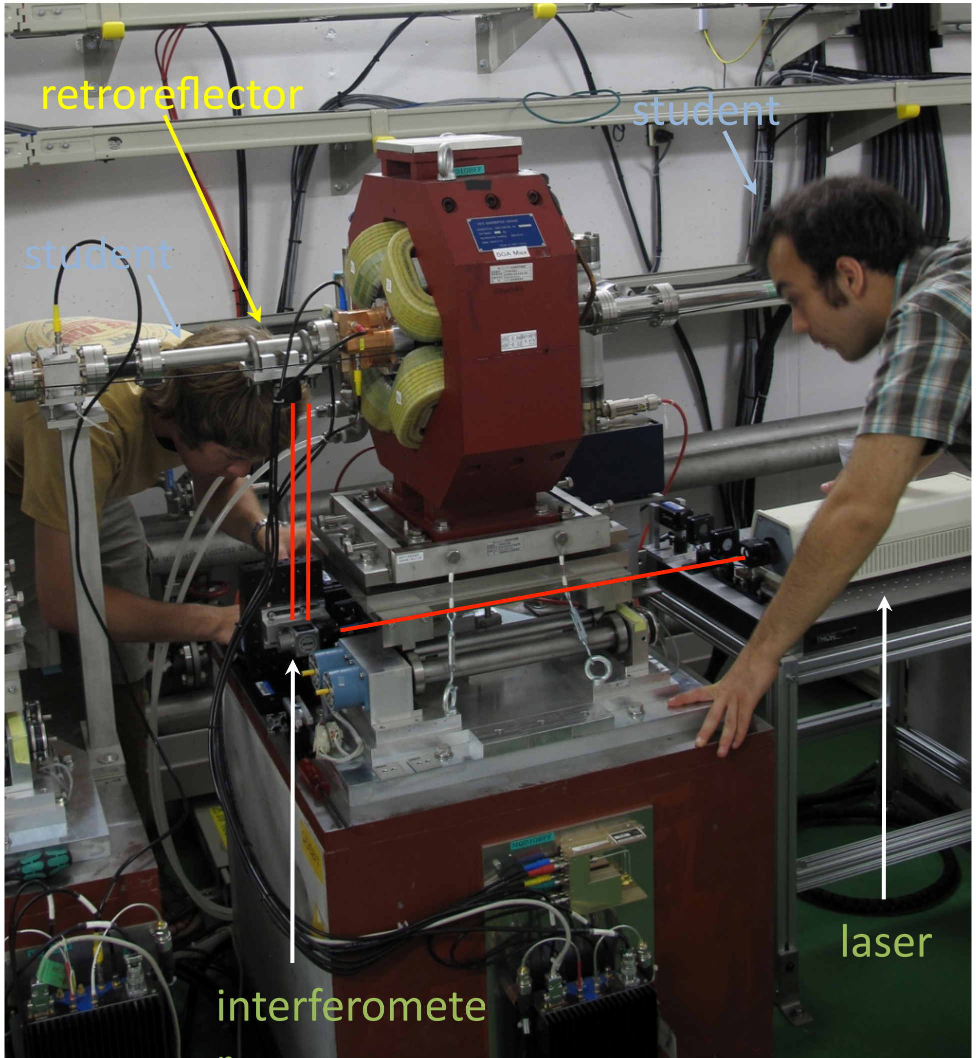
monitor relative (later, absolute) vertical positions of the two IP Steering feedback BPMs

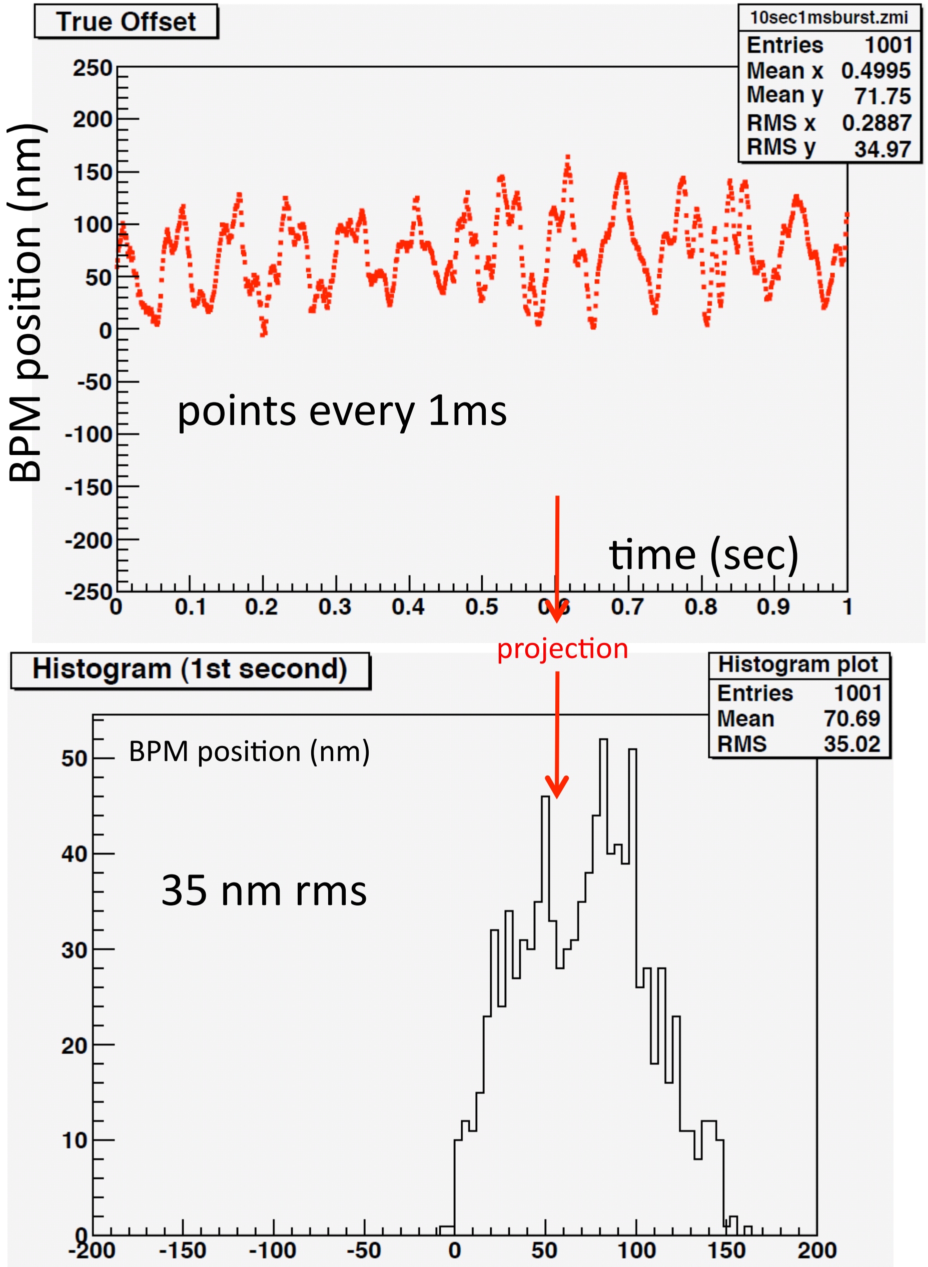




Installed in July 2009

Initial Data: BPM Vibration





Summary

There are a lot of exciting activities for the instruments at ATF/ATF2 under the international framework.

They are continued to realize the goals,

1. demonstration of compact Final Focus optics, a nominal 35 nm vertical beam size, by 2010.

2. stabilization of 35nm beam over various time scale by 2012.

- backup slides -

FONT : Fast feedback R&D

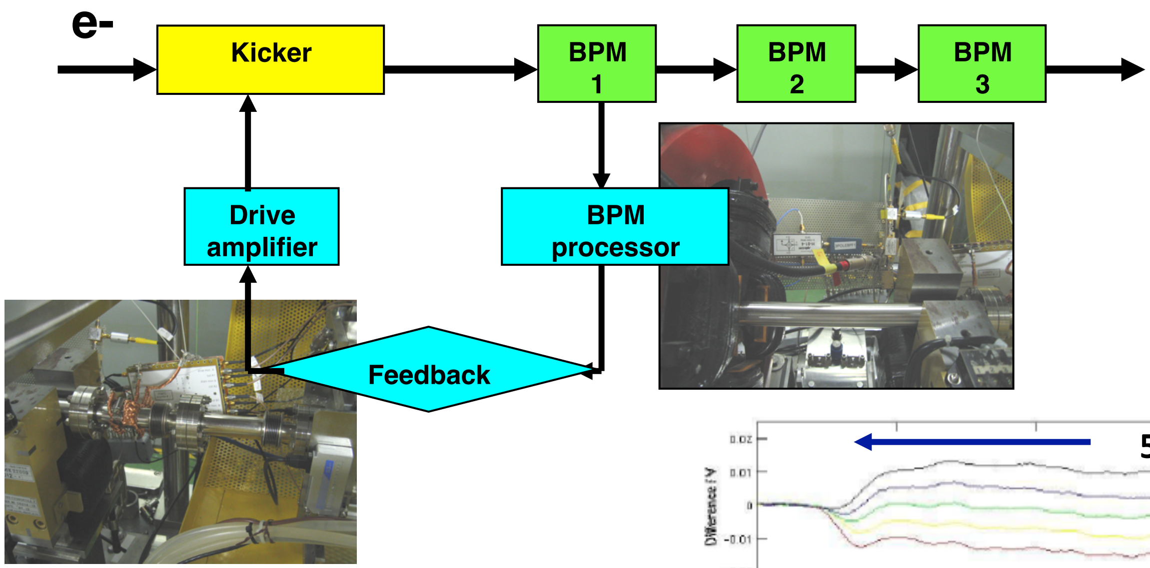
Oxford, Daresbury, QMUL, SLAC, KEK, DESY, CERN

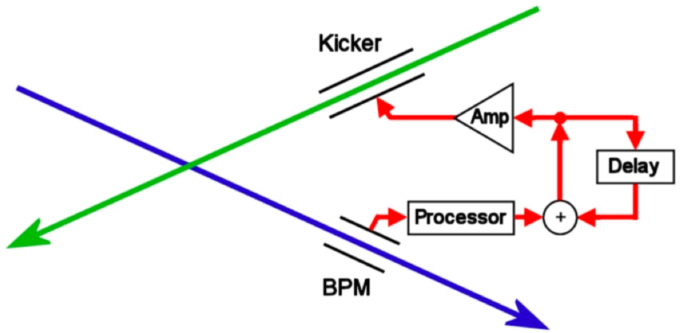
History of latency

FONT1 (NLCTA) : 67ns

FONT2 (NLCTA) : 54ns

FONT3 (ATF) : 23ns





*FONT3:**Analog feedback***

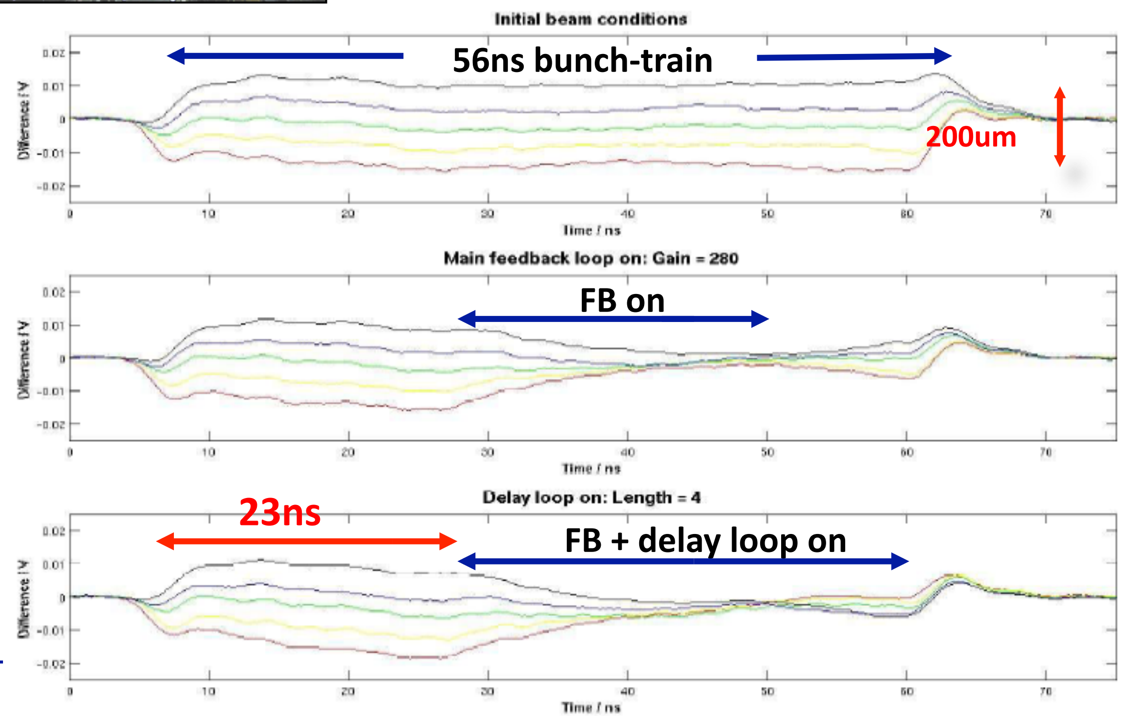
(June 3 2005):

20 bunches with 2.8 ns spacing

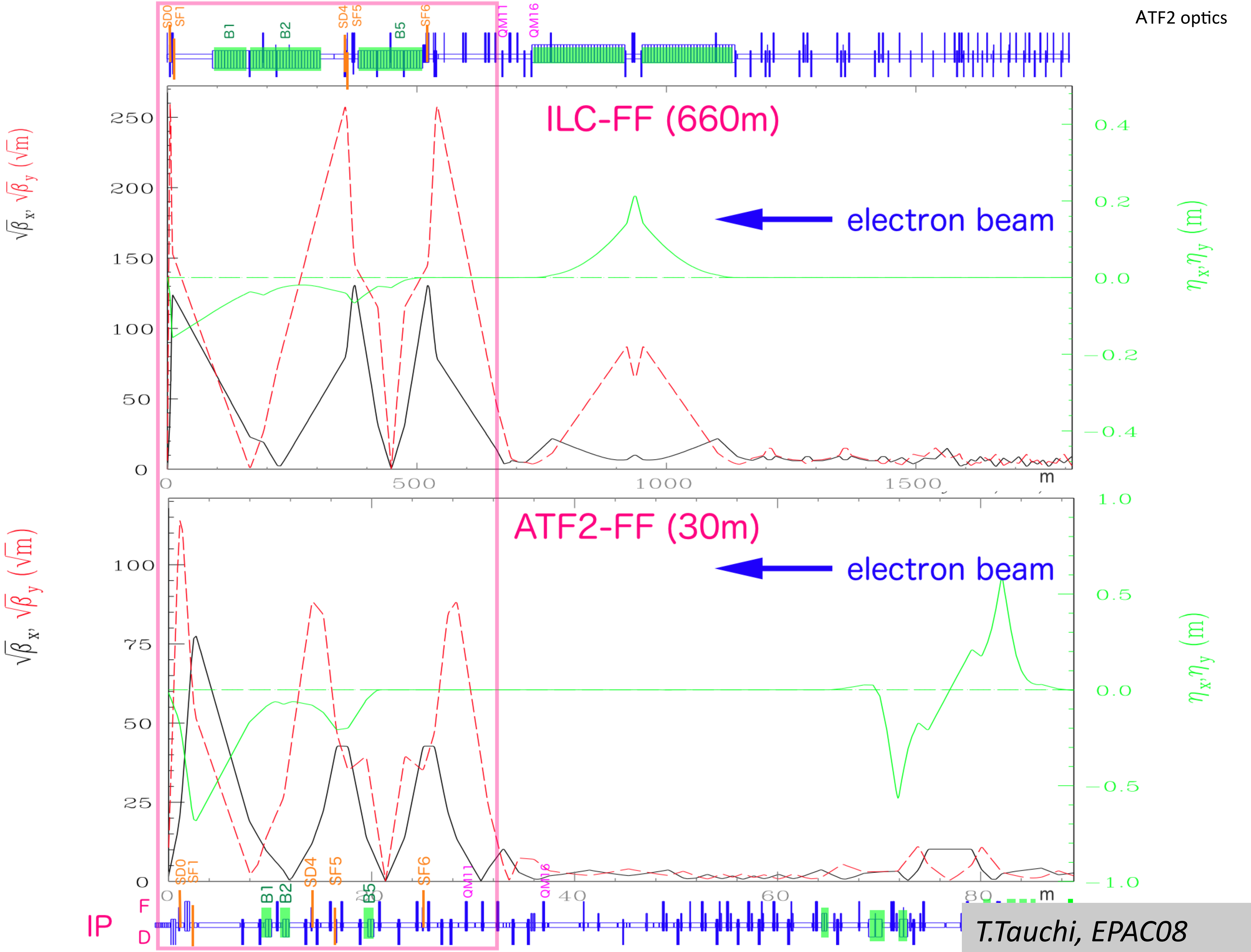
↓

ILC 154/308 ns spacing

FONT4: Digital feedback



ATF2 optics

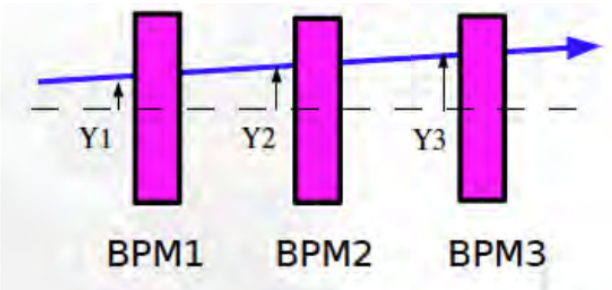


T.Tauchi, EPAC08

nm-BPM (Cavity BPM) R&D

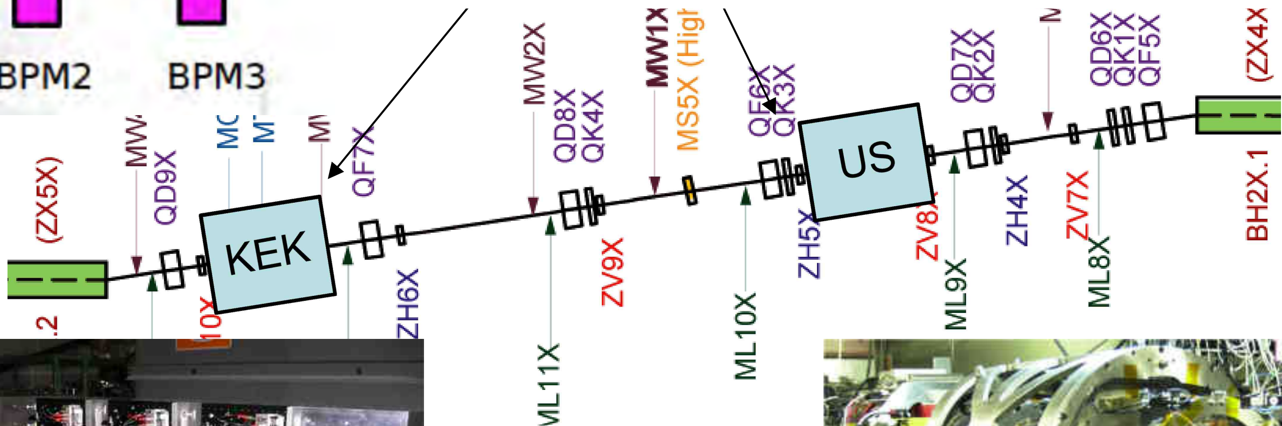
Nanometer position resolution BPM

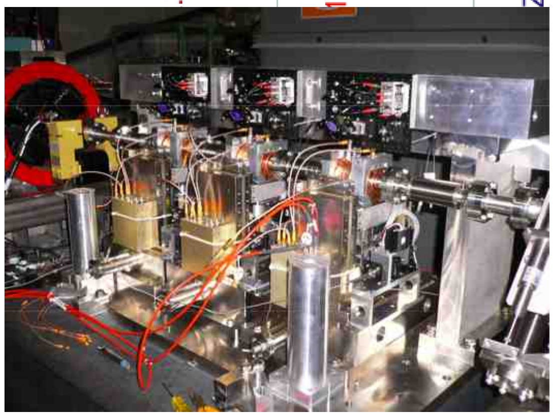
Resolution, systematic errors, calibration process

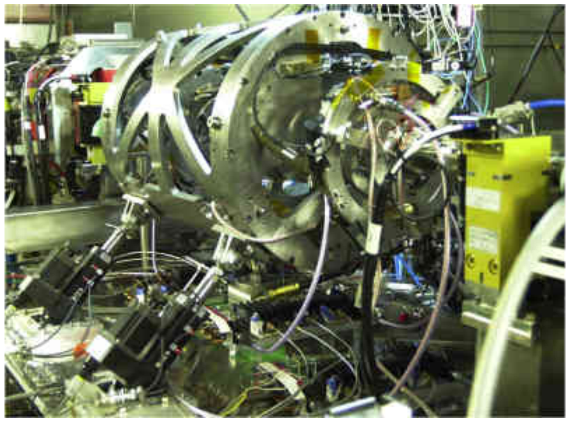


2 cavity BPM triplets in the ATF Extraction line

Different idea of support and position control



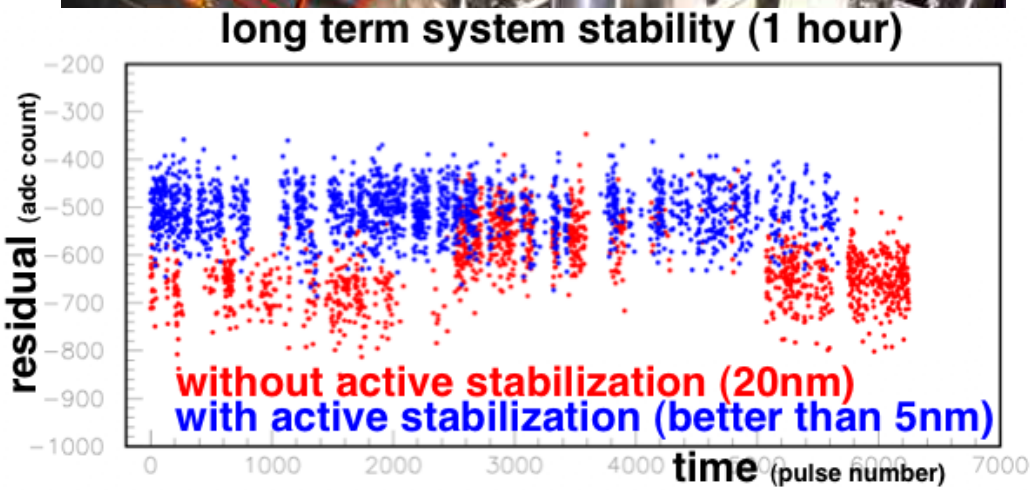


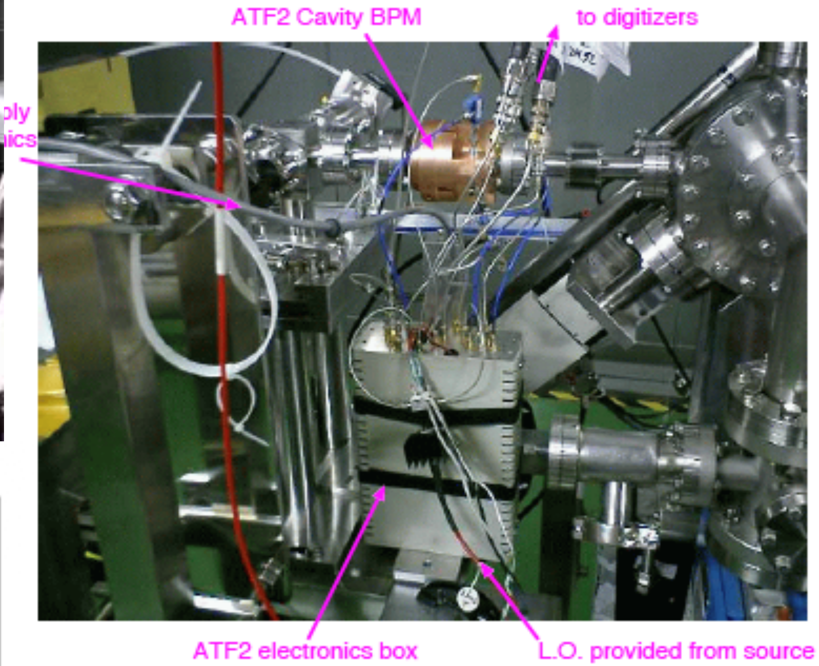


Cavity BPM – downstream triplet (KEK) –

- KEK Cavity BPMs
- Active stabilization system by Optical interferometer

Beam test of prototype BPM for ATF2
(KEK and PAL)





IP-BPM

Beam test at ATF extraction line

@0.7x10^10 e/bunch, dynamic range: 5 um

Achieved resolution

8.72 +-0.28(stat) +-0.35(sys) nm

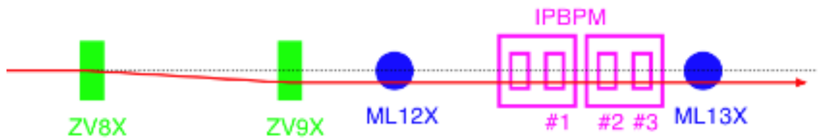
to 2nm → Stabilization of Temperature, Stabilization of extracted beam

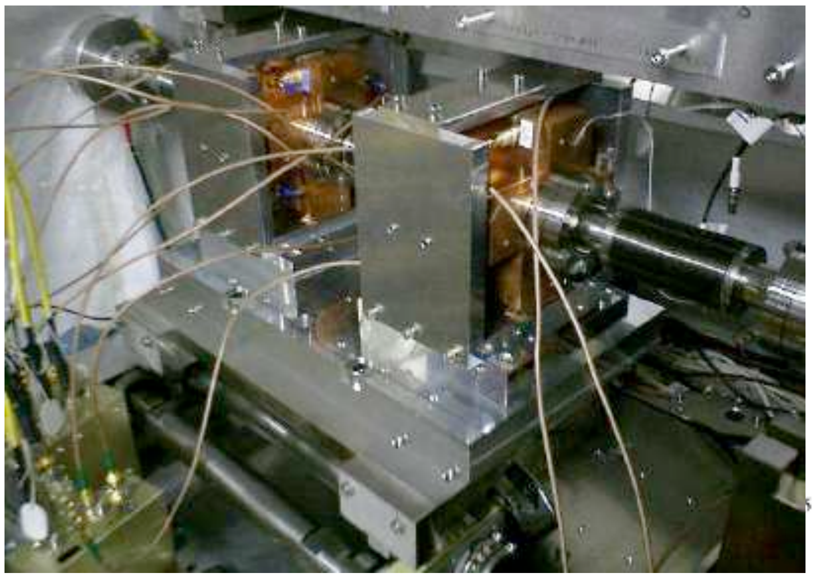
electronics noise limit:

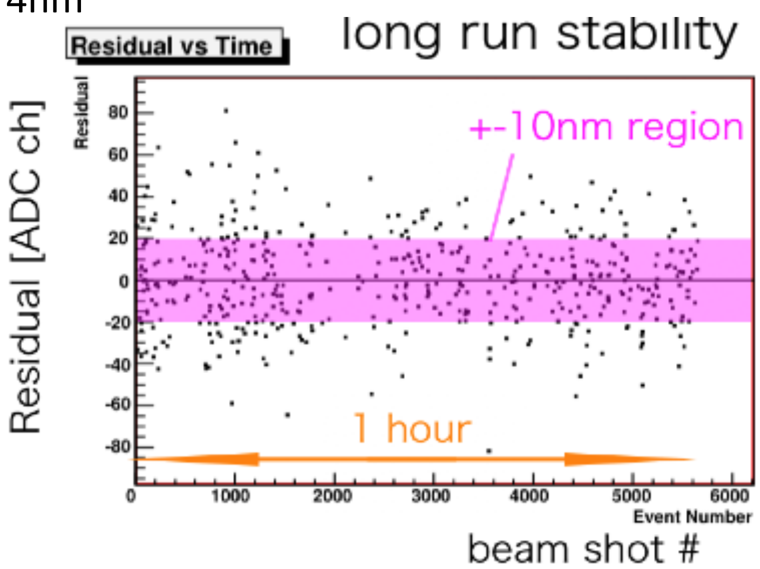
5nm@0.7x10^10 e/bunch

unknown noise: 7 nm

vibration measure by laser interferometer: 4nm

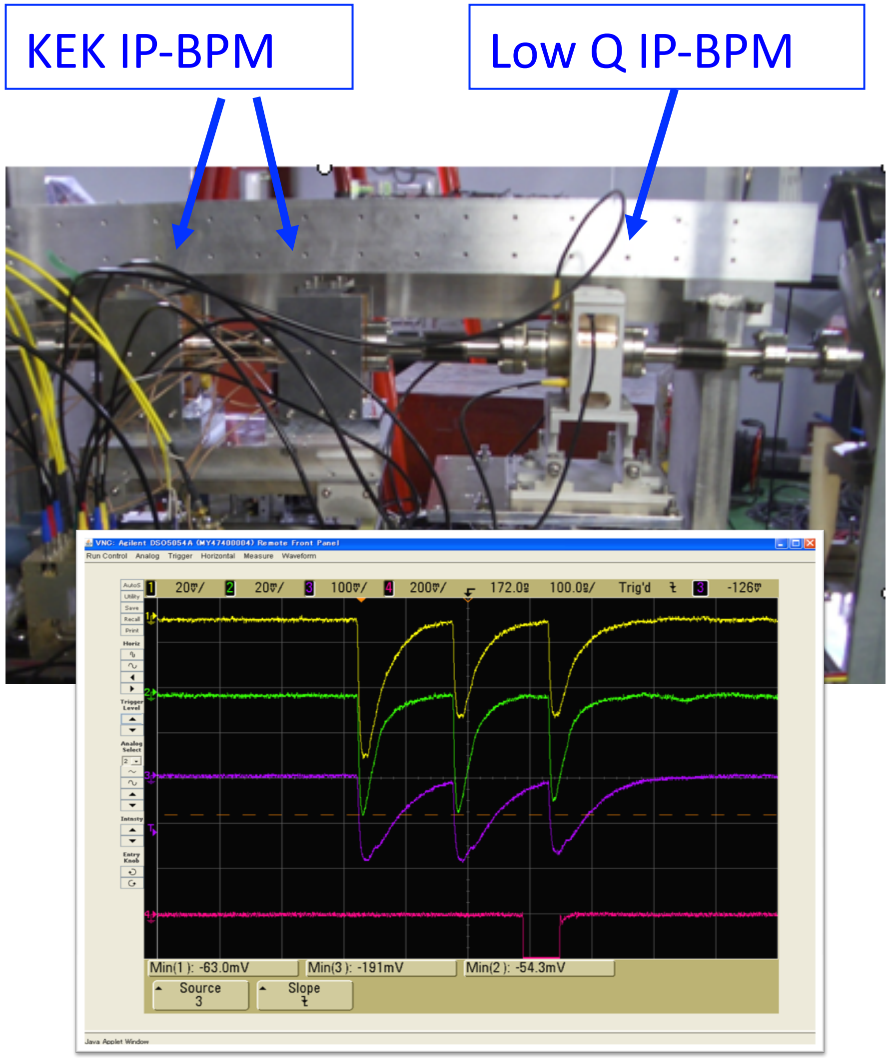




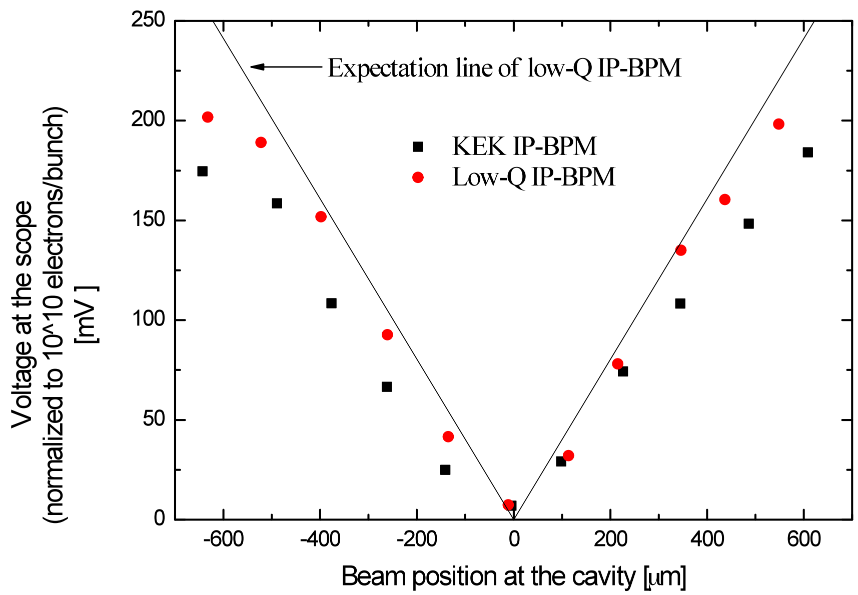


KNU Low Q IP-BPM

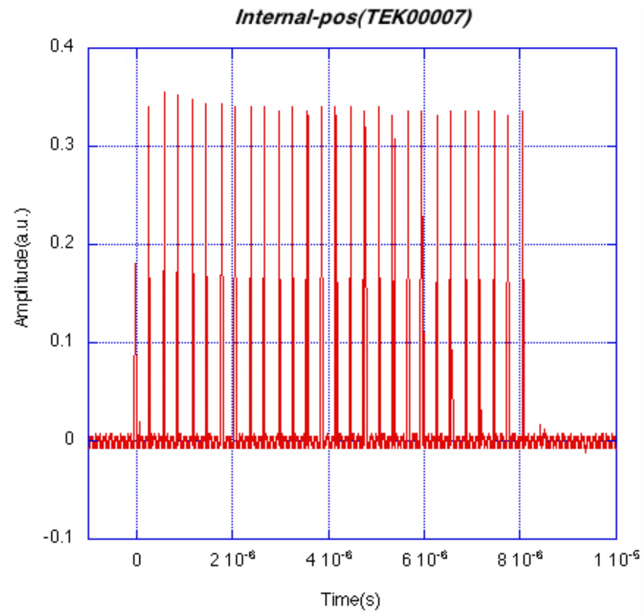
Fast signal decay for multiple bunch operation

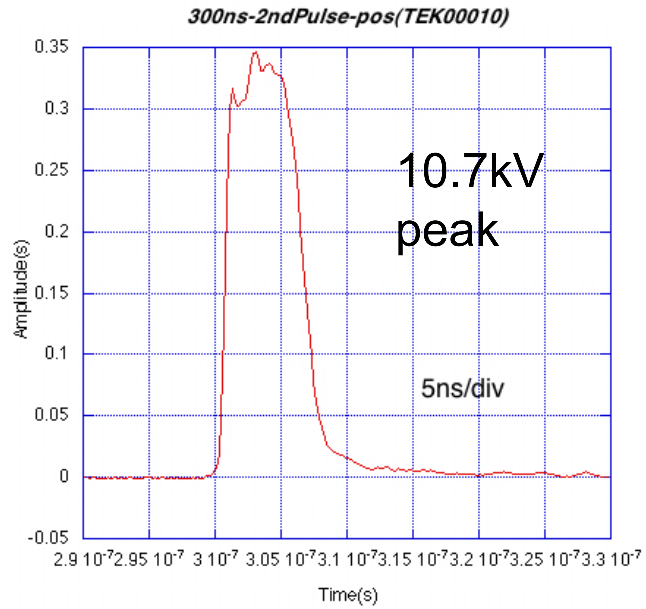


- Position sensitivity test performed, consistent with expectation
- **Bunch separation achieved in 154 ns interval**



FID 10kV, 4ns pulser





To increase the kick angle, we ordered 4ns pulse width pulsers (FPG10-3000N2G) to FID. The kick angle increases 25%.