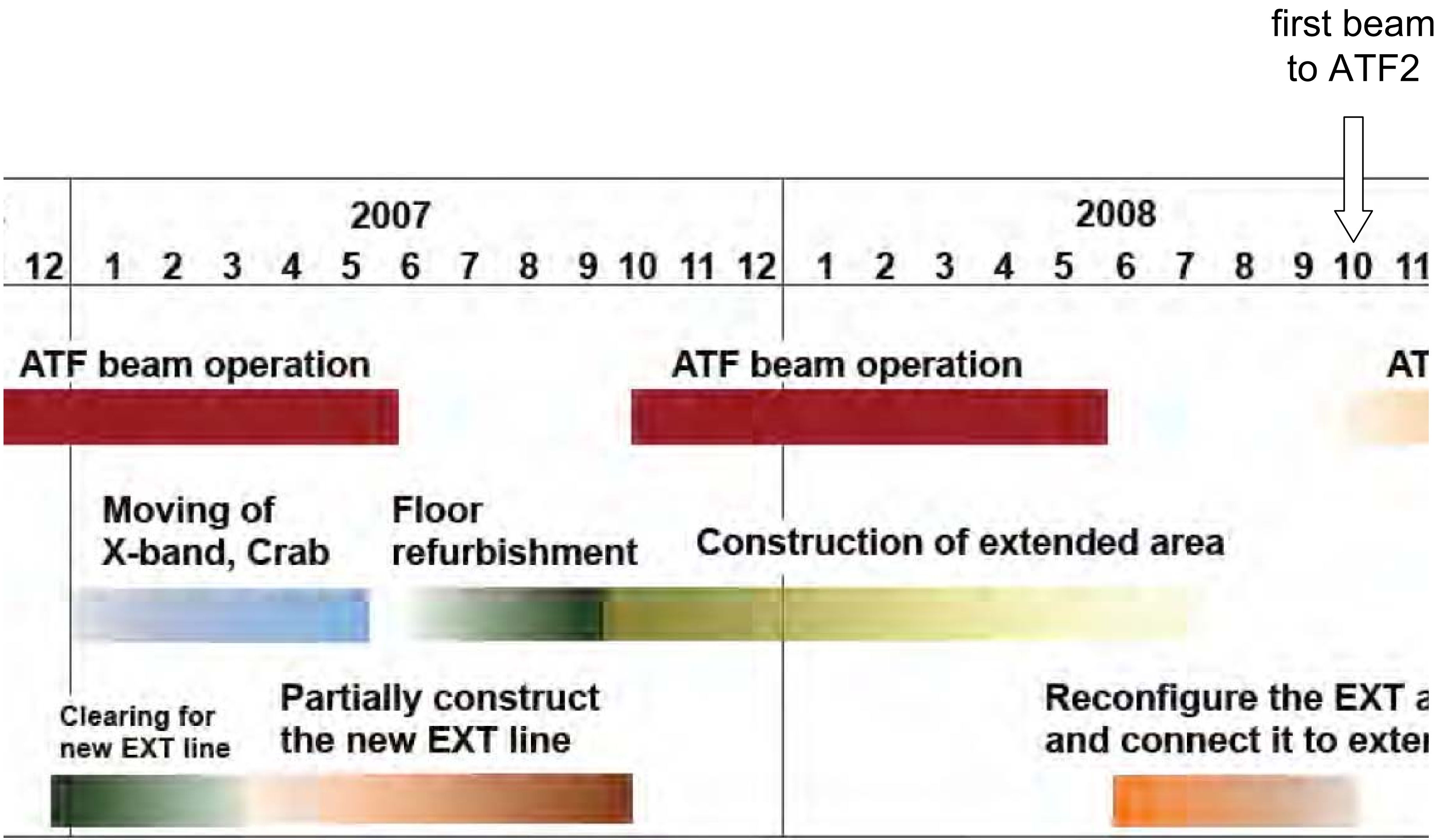
Summary of
3rd ATF2 Project Meeting

18-20 December 2006, Tsukuba

M. Woodley

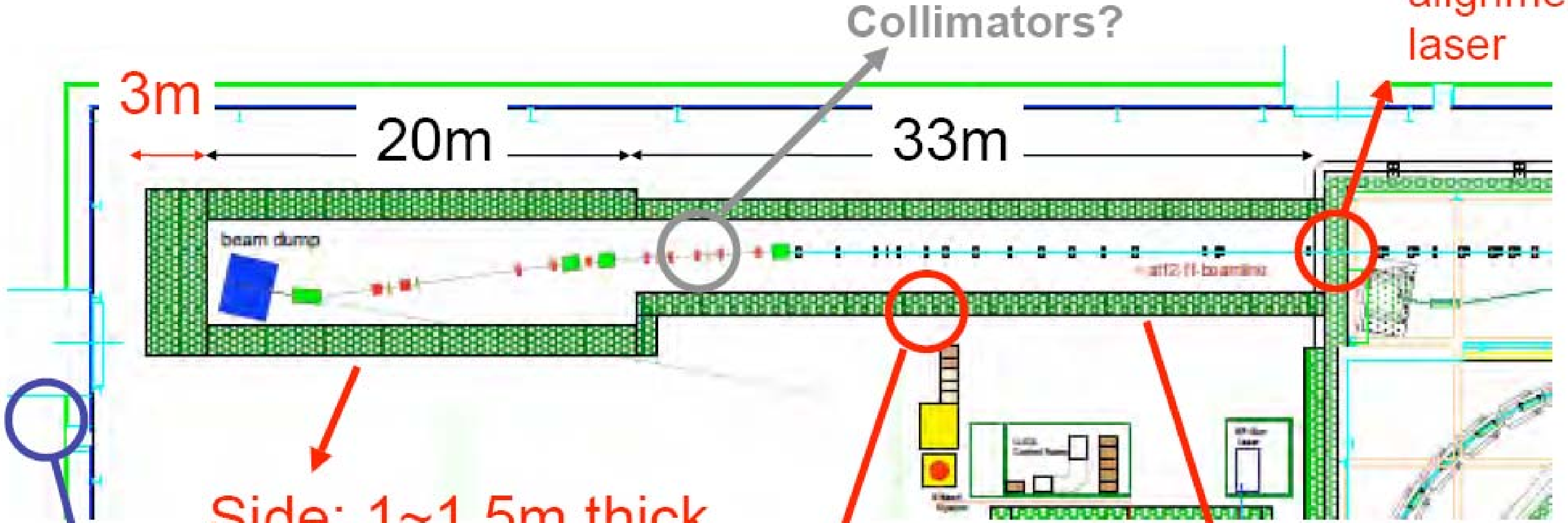
ATF2 Progress (1)

- General
  - schedule
    - floor: summer 2007
    - EXT: partial construction 2007 ... rebuild and connect to FF summer 2008
    - first beam: October 2008
  - layout of FF enclosure, shielding requirements
  - will need special optics for "1 um" laserwire
- EXT
  - strong sextupoles for chromatic correction ... coupling from vertical orbit offsets (do we need to do the chromatic correction in EXT to make 35 nm spots?)
  - alignment group believes 150 urad (rms) roll alignment possible
  - might need 2 new skew quadrupoles (0.2-0.5 T integrated strength) for coupling correction
  - still need to choose best method for correction of anomalous vertical dispersion
  - more simulations to come …
- FF (see Cherrill's presentation ...)
  - Andrei's reduced U3224 optics … tracking codes in good agreement
  - Glen White showed FF tuning simulations using IP BPM ($\sigma > 100$ µm) and Shintake BSM ($\sigma < 100$ µm)
  - additional BSMs near IP to be installed for commissioning (carbon wires, "Honda monitor")
  - B1,2,5 dipoles designed; request for bids on 2006-12-20
  - design for sextupoles proposed (32 mm bore for SD4,SF5,SF6; 50 mm bore for SD0,SF1)
  - maybe CERN table is not the best choice for final doublet ... rigid mounts for final doublet and Shintake monitor (coherence of ground motion)


first beam
to ATF2
2007
2008
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11
ATF beam operation
ATF beam operation
AT
Moving of
X-band, Crab
Floor
refurbishment
Construction of extended area
Clearing for
new EXT line
Partially construct
the new EXT line
Reconfigure the EXT a
and connect it to exte

Radiation shields

Holes for
beam pipe,
alignment,
laser



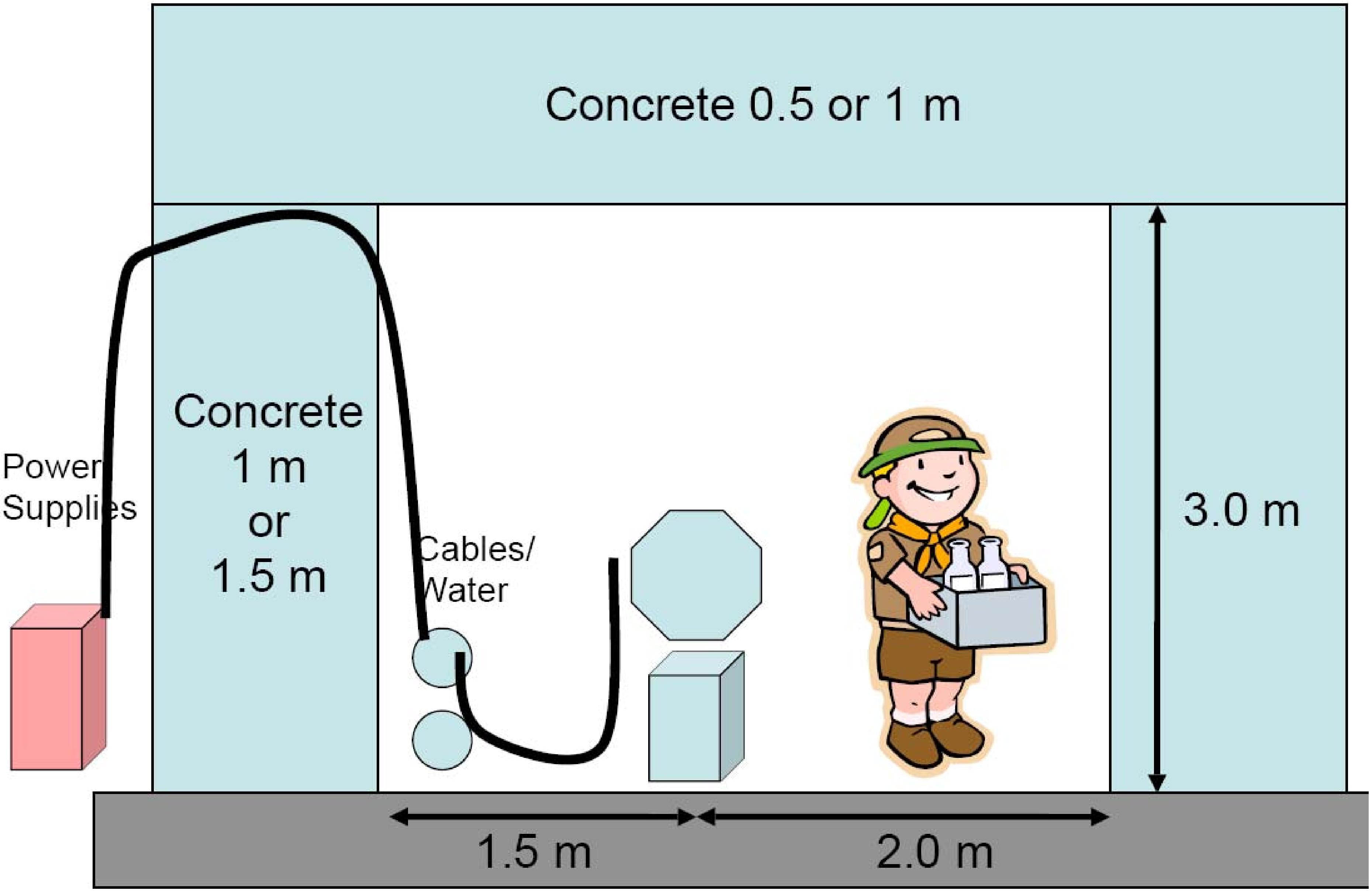
Side: 1~1.5m thick
Top: 1m thick
Inner width: 5m

Access
Entrance
Moving shield door

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

Public area: < 0.2 μSv/h

Penetration holes (water pipe, cables,…) should be well designed.



Concrete 0.5 or 1 m
Power Supplies
Concrete 1 m or 1.5 m
Cables/ Water
3.0 m
1.5 m
2.0 m

ATF2 Optics Version 3.6 Issues

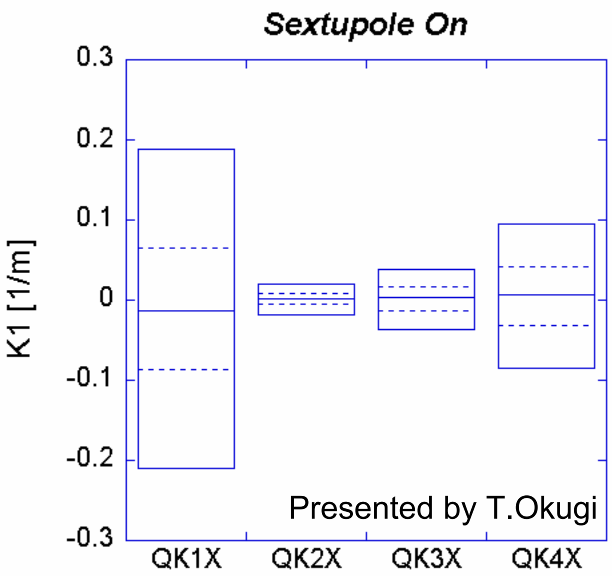
Discussion and …

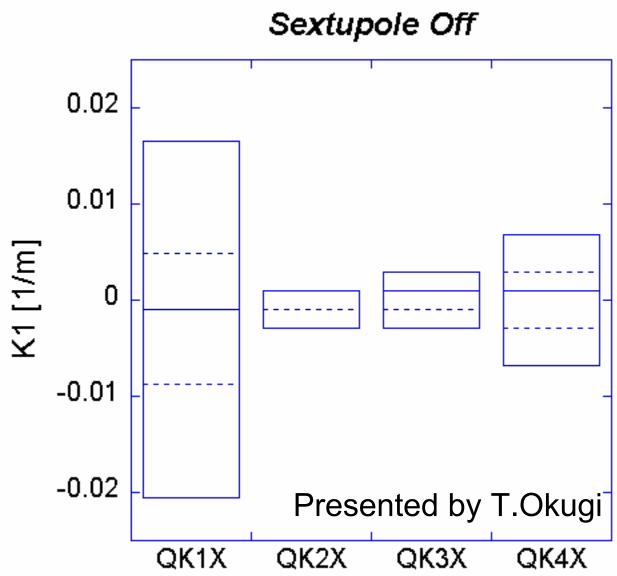
- BH3 (Sumitomo Heavy Industries type "C") … can it run at 110% of it's present strength?
  - Yes, but we have to take care the sector type of the edge shape.
- need to get another FFTB "1.38S3.00" sextupole from SLAC for EXT
  - We need more detail study.
- cavity BPMs on EXT quads with no movers (QD18X, QF19X, QD20X, QF21X)?
  - Yes, we don't need additional devices.
- kicker cables (kickers are 8.2 m / 35 ns further apart)
  - One possibility is to move the kicker PS.
- compact laserwire package design (laserwire chamber + wire scanner + BPM(s))
  - See the summary of relocation session.
- where to put: KEK BPM triplet, nanoBPM, FONT4, ODR, … ?
  - See the summary of relocation session.
- MAD deck for FF is still sketchy … need to put in BPMs, movers, etc.
- need to do more misalignment/correction and performance simulations (including realistic wire scanner resolutions, extraction channel errors, …)

Skew quadrupole Issues (Homework)

Toshiyuki Okugi estimated
the strength of skew quadrupoles again

All sextupoles off





Strengths of the skew quadrupoles were reduced by 1/10.

Main coupling source was vertical offset at sextupoles and bends for strong sextupole fields.

Further homeworks - Find the good sextupole setting.

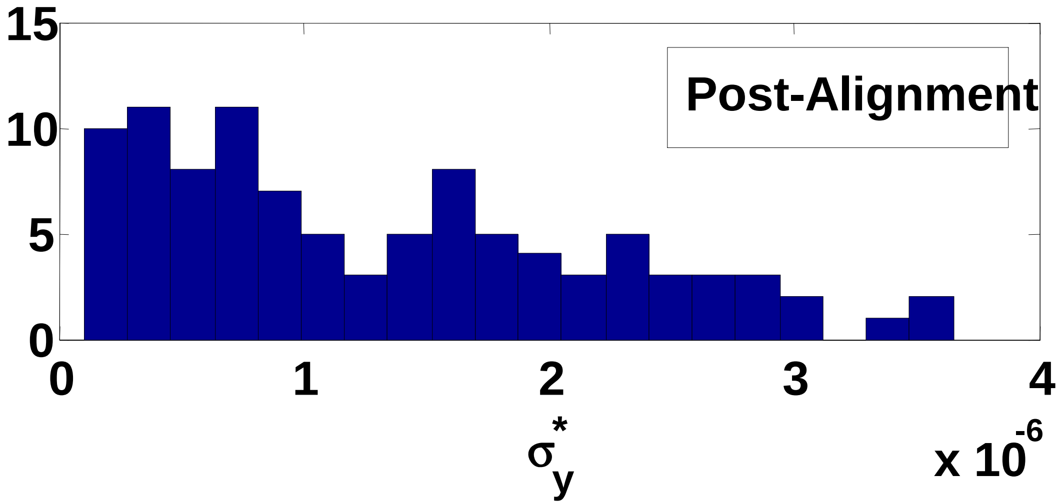
- **small chromaticity**
- **small 2nd order dispersion,**
- **small betatron coupling**

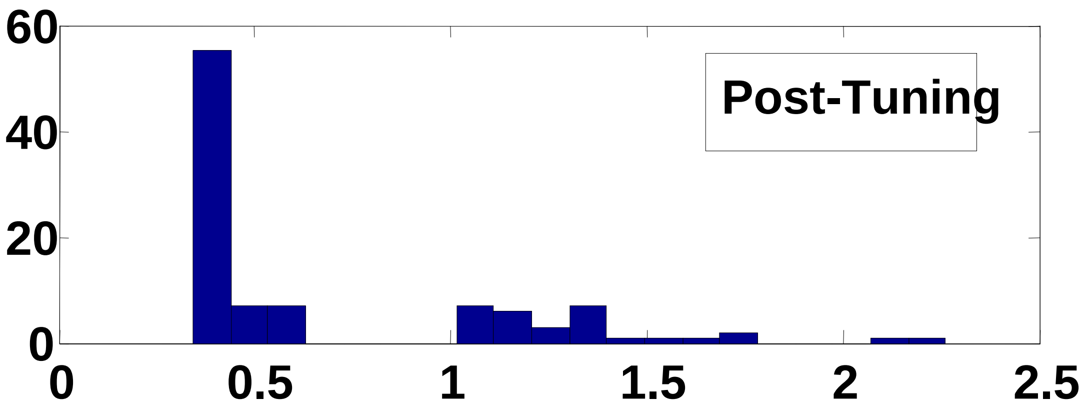
Beam Tuning Issues

Glen White investigated the tuning method.

> 100nm with IP-BPM

< 100nm with Shintake monitor



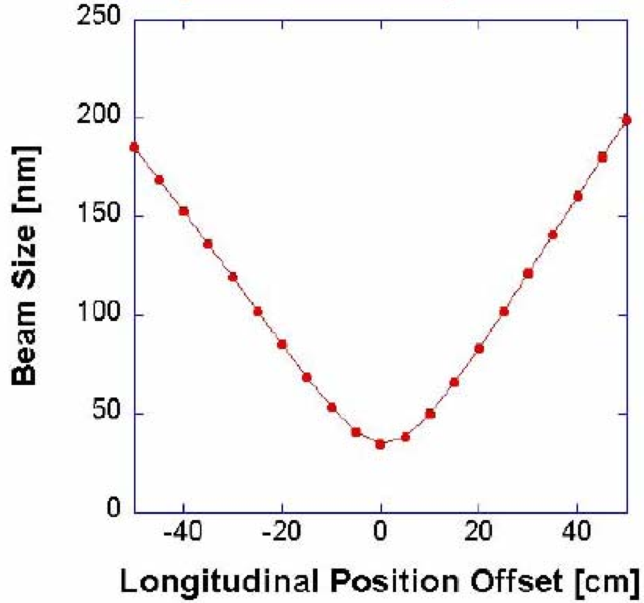


σ_y^* x 10^{-7}

- More work needed getting all seeds to converge.
  - Evaluate order of knob application.
  - More averaging per scan.
- Convergence typically in <20 iterations:
  - Assuming 1 min per IP spot-size measurement (90 bunches @ 1.5Hz), 10 scan points per knob iteration and 1 cycle through Sext tilt/dB scans:
  - If completely automated, tuning would take ~ 4.5 Hours.
- Need to add Ground Motion, component jitter, incoming beam orbit + energy jitter, BPM scale and magnet strength drifts…

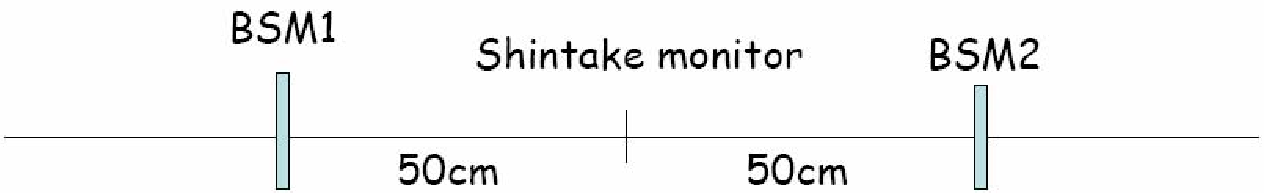
However, we can make the beam size small at non-IP location by changing the strength of the final doublet, QF1 and QD0.

- *No change for sextupole field.*



The vertical beam size at s=+/-50cm Is 180nm.

It is possible to minimize the nonlinear field around IP by using BSM at s=+/-50cm.



Beam Tuning Issues

Toshiyuki Okugi presented about the commissioning devices,
and we discussed …

Conclusion

We need the additional BSMs around IP.
- Carbon wire scanners with 1micron resolution.
- Honda monitors with 0.3micron resolution.

We need the sweeping magnet for the position scan for IP BSM.
- Shintake monitor have the phase scanning system.
- Honda monitor plan to make the position change mechanism.
  However, we need the sweeping magnet as backup devices.
- The sweeping magnet is also useful for the carbon wire scanner.

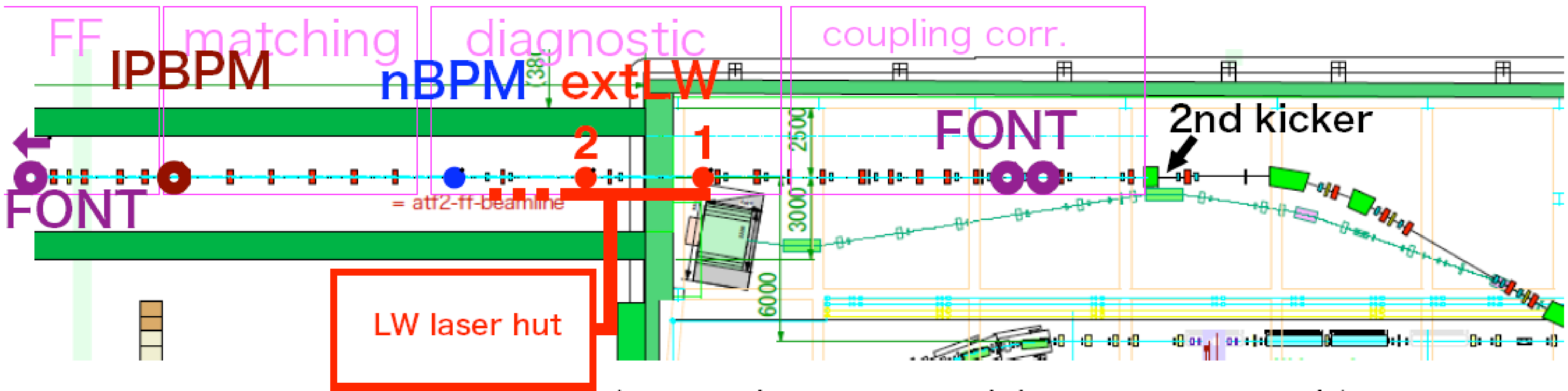
ATF2 Progress (2): Diagnostics & Instrumentation

- locations chosen for: laserwires, nanoBPM, IP-BPM, FONT
- feed-forward system proposed by Alexander Kalinin (vertical only)
  - correct fast bunch-to-bunch jitter in a bunch train
  - correct drift in bunch train shape
  - correct drift of entire bunch train
  - correct +-6 sigma to +-0.1 sigma
- Shintake monitor
  - 10 nm phase stabilization demonstrated (gives +-2 nm error on measurement of 35 nm beam size with a safety factor of 3)
  - detector: two-layer CsI scintillation calorimeter (10 x 5 x 2+30 cm)
- "casette tape" BSM ("Honda monitor")
  - for measuring beam size between 1 um and 350 nm ("blind spot": too small for wire scanner, too large for Shintake monitor)
  - thin film with applied fine strips
  - beam destroys detector ... move tape for each measurement
  - small beam -> two peaks; large beam -> single peak ... tune on separation

Re-location session summary

1hour session on 18Dec.2006, convener:Y.Honda

- so far no quarrels between groups
  - Ext.LW
    - micron-size at 1, 2D system at 2, may extend later
  - nanoBPM
    - to be used as a BPM test stand
  - IP-BPM
    - one of the section at the matching section
  - FONT
    - start at upstream area, reserve a section for IP stabilization in future
- Before finalizing the layout
  - beam optics should be checked by each group
  - space clearance including girder have to be checked
  - procedure to move the devices has to be considered well

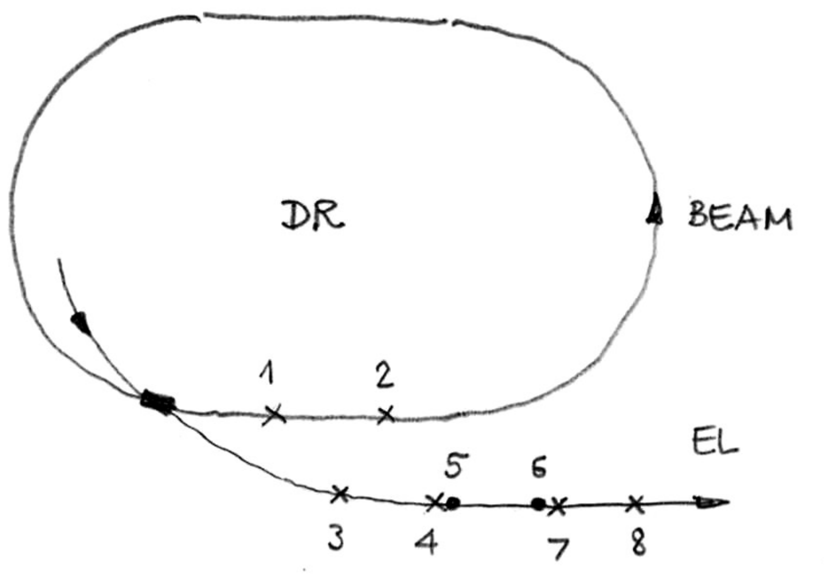


(open circle means around this area as an example)

Turnaround Feed-Forward Prototype at the ATF

Prototype set-up

- The upstream BPM pair in the DR: 1 and 2
- The Kickers in the EL: 5 and 6
- A BPM pair for matrix measurement: 4 and 7
- A BPM pair for feed-forward gain adjustment: 7 and 8
- A BPM pair for excluding ATF extraction kicker jitter: 3 and 4



ILC jitter is modelled using some set of standing betatron waves excited in the DR with its orbit correctors. On the last turn the particular wave propagates to the EL where it is corrected with the kickers. The correction residue is measured with the downstream BPM pair.

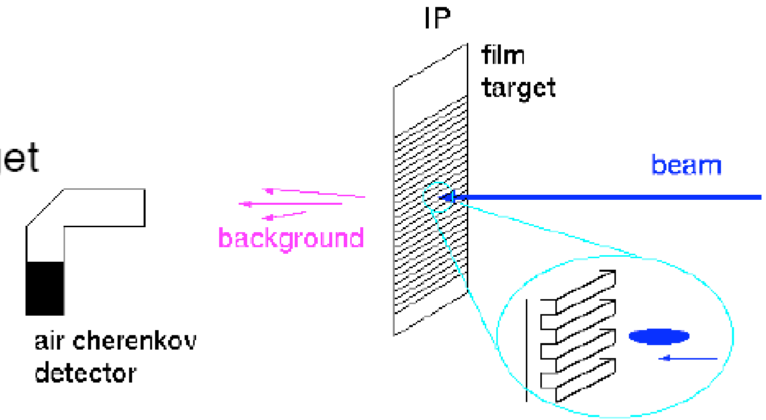
The matrix is measured using same betatron waves.

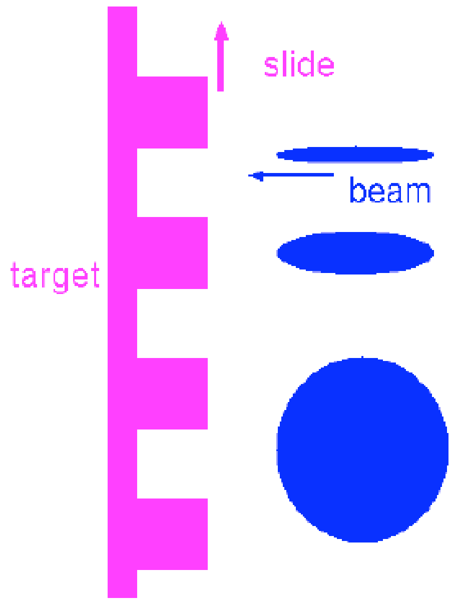
The kicker jitter is measured and used to find correction net effect.

“Honda Monitor”

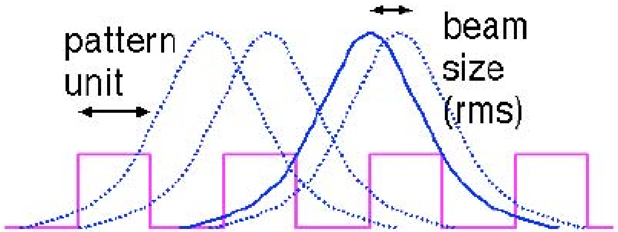
principle

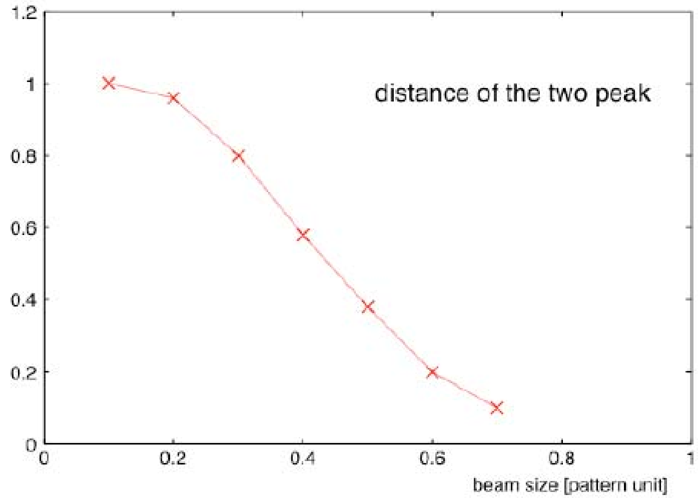
- Put a thin film target that has a fine structure in its thickness
- Beam produces a background when it hits the target
  - yield will be proportional to the convolution of beam density and the thickness of the target
  - wire-scanner type detector
- Beam size measurement
  - measure the fluctuation of the signal yield
  - small beam: signal strength becomes two states, beam hits at thin area or thick area.
  - large beam: constant signal strength
- Expendable target
  - The target may be destroyed by the beam. Move the target in each beam pulse to use new area.
  - position is not controllable
    - statistical approach
    - works even if beam position has a jitter

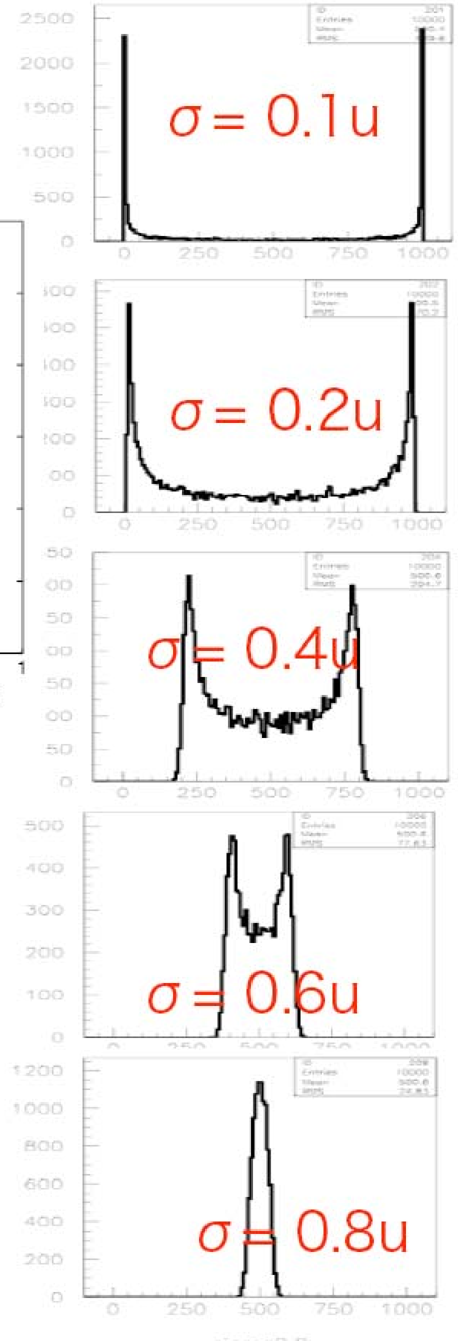




example



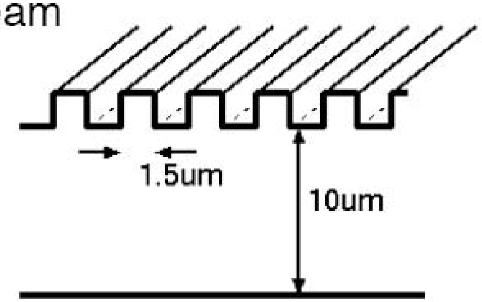


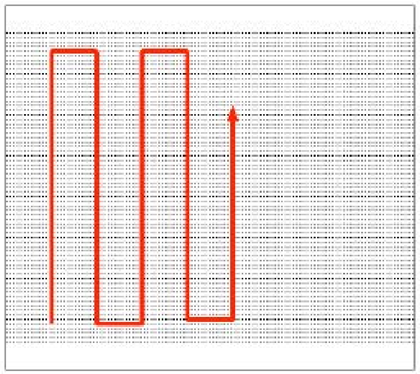


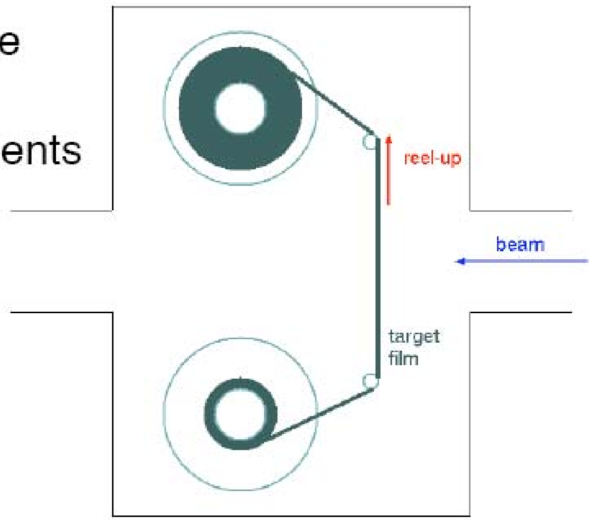
- This is just a mathematical calculation of the convolution of
  - gaussian shape beam
  - rectanglar shaped pattern target
- fluctuation of the signal in many pulses assuming random beam position
- distance of the two peaks is a good measure to estimate the beam size
  - beam size is bigger, distance becomes narrower
  - sensitive if beam size is in the range of 0.2~0.7 pattern unit

requirements on the target

- structure of the pattern
  - pattern unit should be ~1.5um to measure 350nm~1um beam size
  - thin film to prevent multiple scattering
  - high contrast, say better than 10%
  - edge sharpness may be not so important for relative measurement, uniformity should be important
- size of the target
  - assume 1000 pulses (10min.) for one measurement
  - slide ~10um in each pulse makes 10mm of length for one measurement
  - 1m length target is needed if we assume 100 measurements in one week
- system design
  - reel film mechanism
  - use plate along zigzag line







Recent Work at ATF

Taken from Technical Board Meeting presentations

- Damping Ring
  - last 4 DR wigglers removed (August) ... no wigglers in DR
  - Tokin 3581 ("6cm_42p","wiggler") quads in DR (QM12R.1,QM13R.1,QM14R.1,QM12R.2,QM13R.2,QM14R.2) permanently replaced by 6 QEA (IHEP) quadrupoles
  - beam tuning with CSR signal
  - laser cavity for Compton e+ production experiment to be installed in February
- Fast Kicker
  - 30 cm stripline kicker tested
  - "waveform compensator" reduced measured rise-time from 3.2 ns to 2.2 ns
  - 1.5 m stripline kicker being fabricated
- XSR monitor
- FONT
- EXT Laserwire
  - laser/beam interaction chamber installed
  - Pb-glass calorimeter added to aerogel Cerenkov detector
  - DAQ integrated with EXT stripline BPM readout
  - beam size has been measured
  - beam size ~ 4 um (wire scanner); 11.4 um (laserwire) -> laser size ~10 um
  - next: new f2 laser focusing lens; movers for the chamber
- nanoBPM
  - carbon fiber tube and Thermal/Dynamat enclosure for thermal satbility
  - nanogrid metrology system for monitoring relative motions of BPMs and spaceframe
  - best resolution: 15.6 nm vertical position, 2.1 urad vertical tilt
- IP-BPM
  - dual cavity (doublet) device for position and angle
  - two sets have been installed and tested in existing EXT line
  - resolution ~2.7 nm;
  - position sensitivity ~2-3 times better than QBPM;
  - angle sensitivity ~2-4 times worse than QBPM

Wiggler magnets in DR were removed in August 2006.

Laser Cavity-Compton system will be installed in February 2007

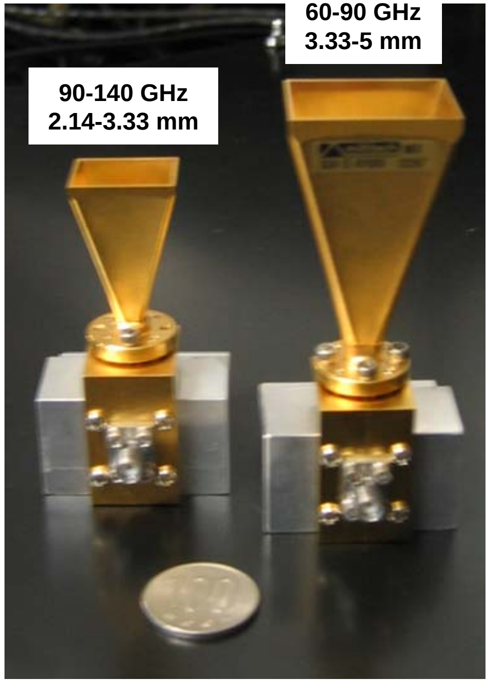
Six Quadrupoles at wiggler sections were exchanged to ATF2's.

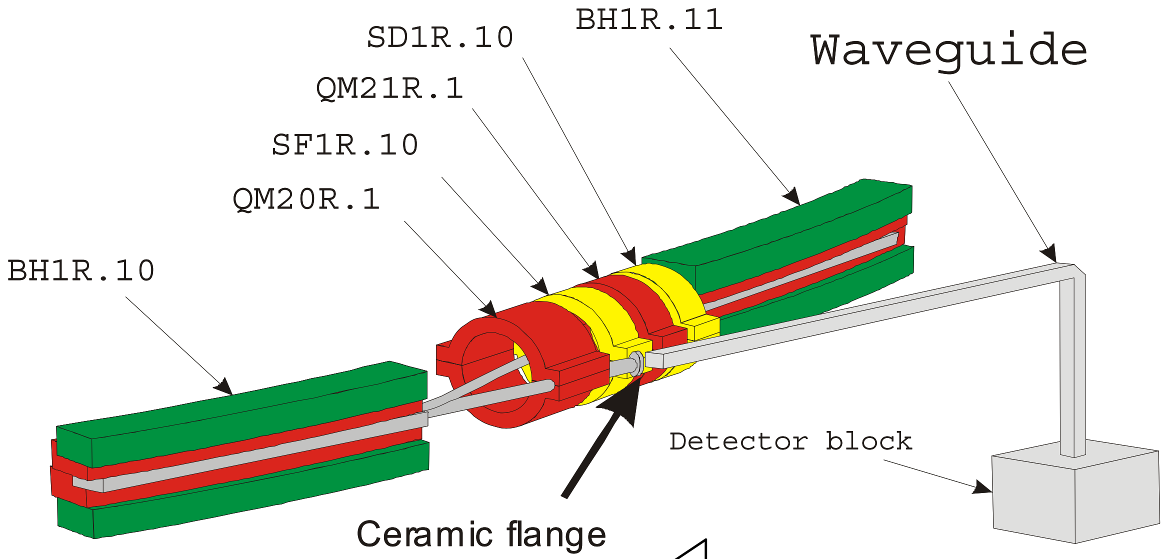
1. Old quadrupoles were for wiggler chambers; bore diameter is 44 mm, thicknes 60mm.
2. We can improve the field quality by exchanging them to the ATF standard one; bore 32 mm.

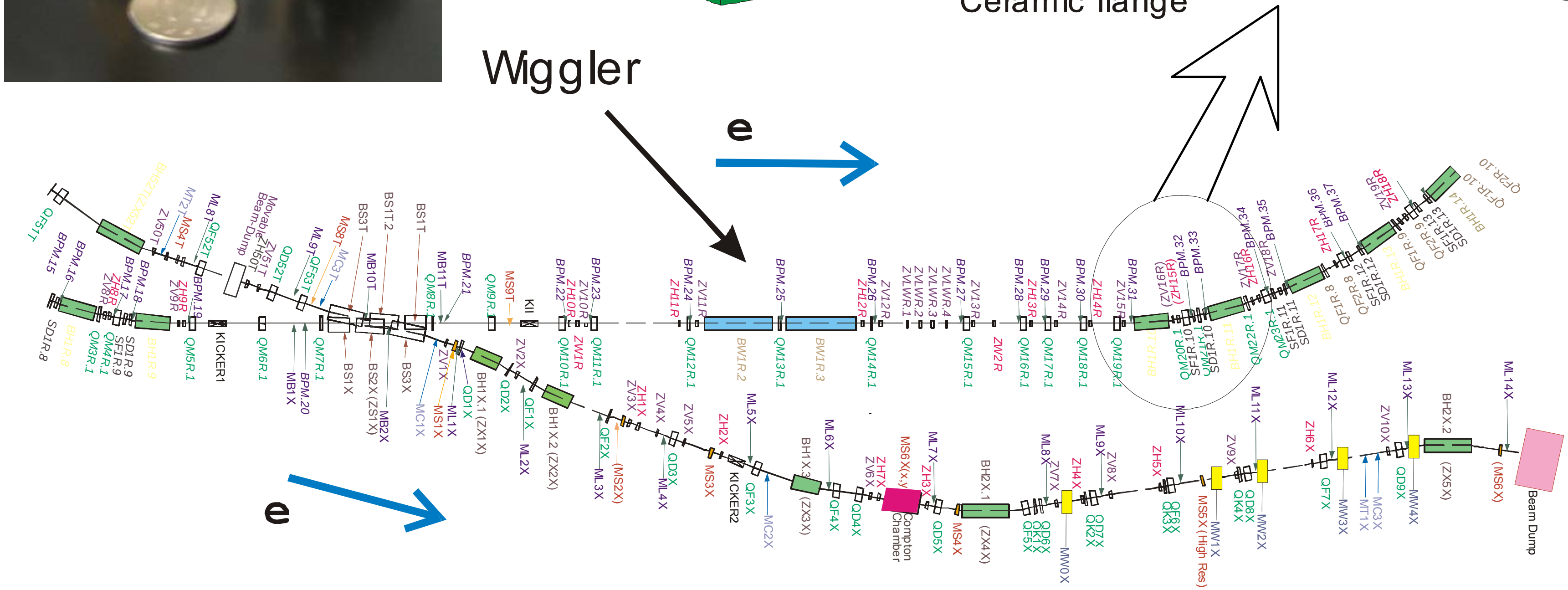
3. It is better to have the operating experience for ATF2 quadrupoles made by IHEP.

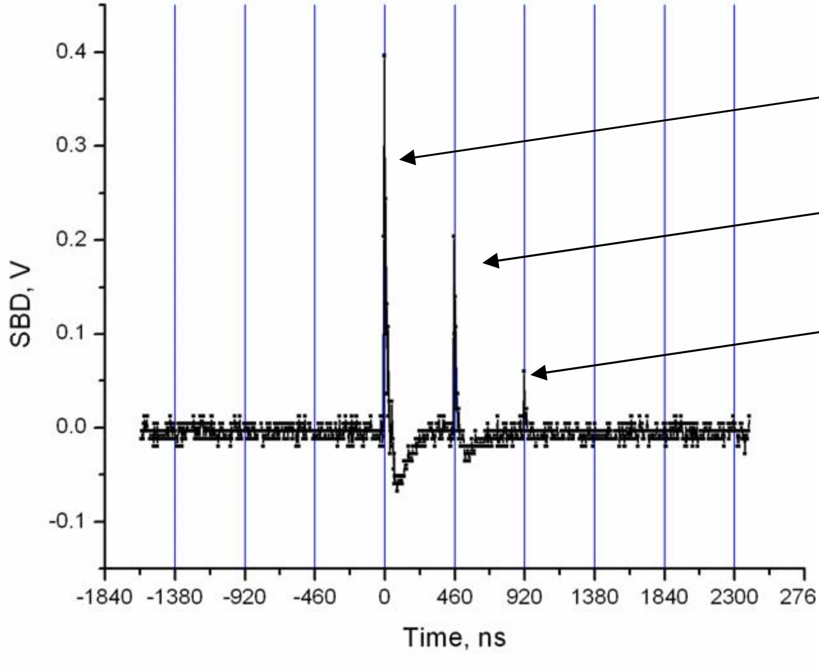
CSR experiment

Schottky Barrier Diodes

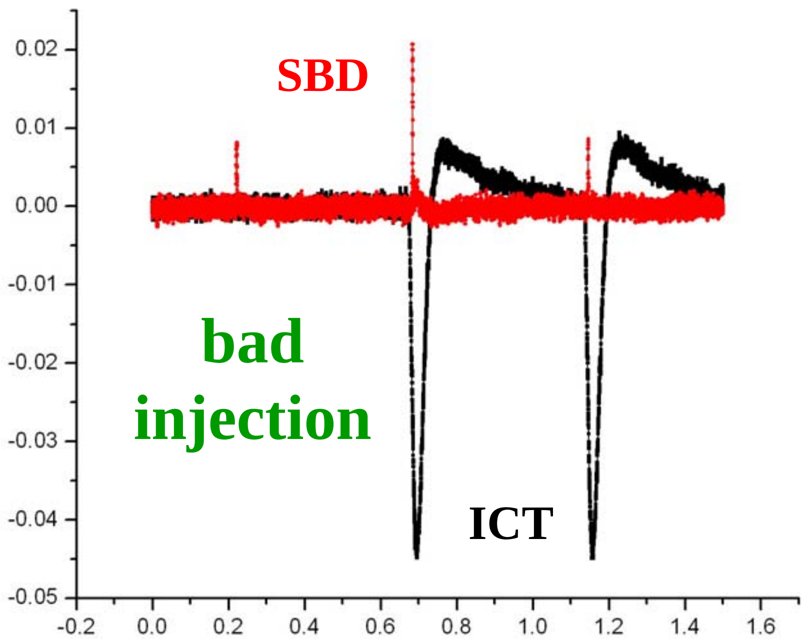


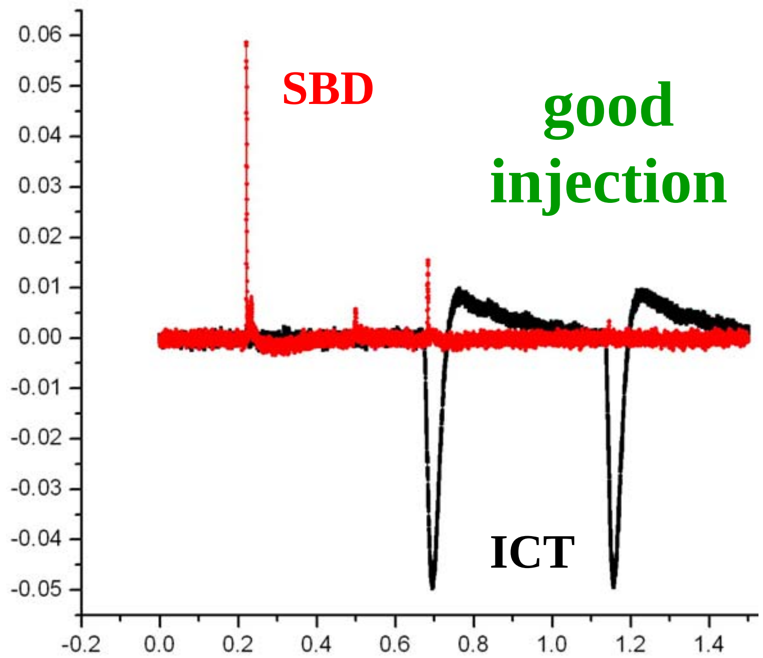






- Using the CSR monitor for injection tuning we already succeed a stable $1.8\cdot10^{10}$ electron/bunch ATF operation with nearly 100% of electron beam transmission from linac to the damping ring
- Still no any microbunch instabilities have been observed at ATF DR at this current

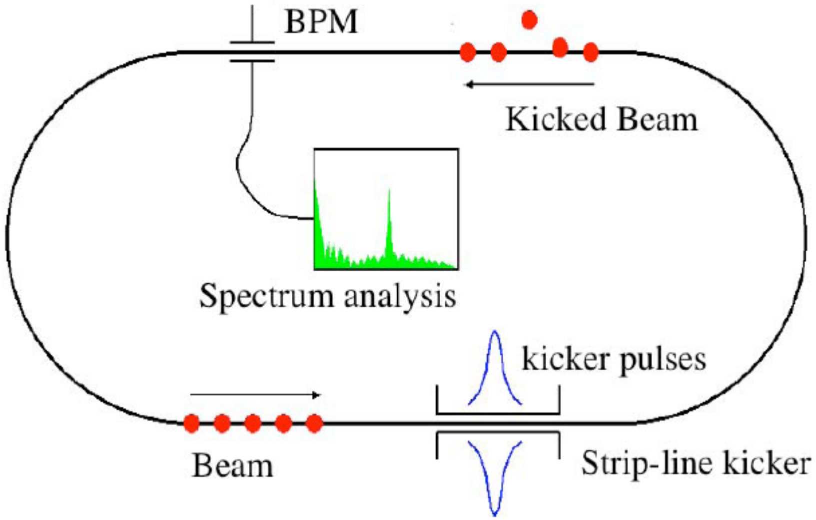




FAST Kicker

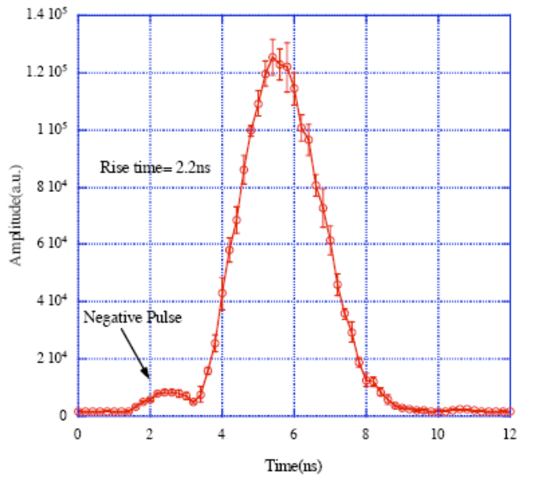
30cm long strip-line kicker test at ATF-DR

Fast Kicker



The time response of the single unit was measured from the excited betatron oscillation amplitude. The measured rise time was 3.2ns w/o the waveform compensator and 2.2ns with the waveform compensator.

Rise time improvement with the two pulses combination

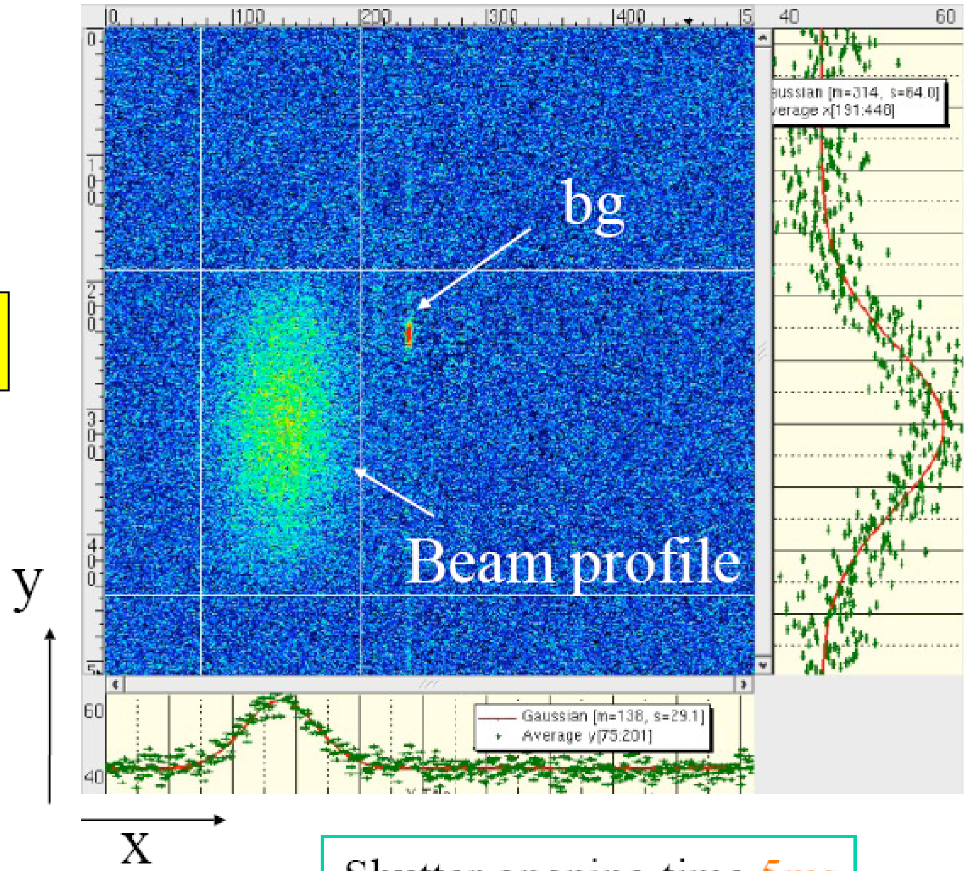


Fabrication of 1.5m long strip-line kicker for beam extraction from ATF-DR to extraction line

The electrode of the strip-line is under fabrication which will be installed at the present kicker section. The beam kick performance will be tested at the linac end before installation.

Measured beam profiles by XSR monitor, Nov 2006

XSR Monitor



Shutter opening time 5ms

FONT4 test plan

June 2006:

1st test of PCB version of analogue BPM processor

2nd tests of digital FB: timing, synchronisation, triggering,
gain adjustment in FPGA
(ADC clocking @ 714/10 = 71 MHz)

December 2006:

1st test of FONT4 amplifier

3rd tests of digital FB: ADC clocking @ 357/4 = 90 MHz

2nd tests of PCB BPM processor

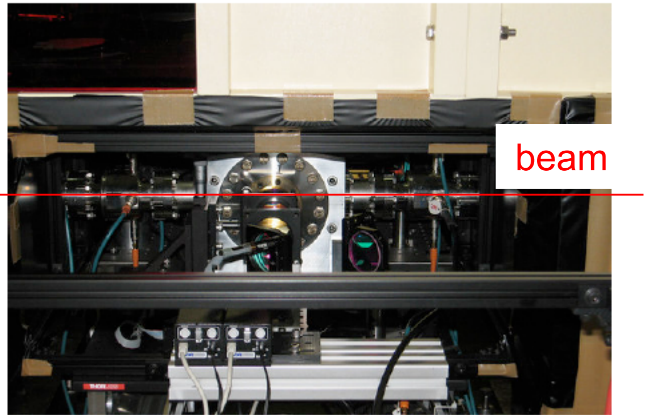
Closed-loop FB

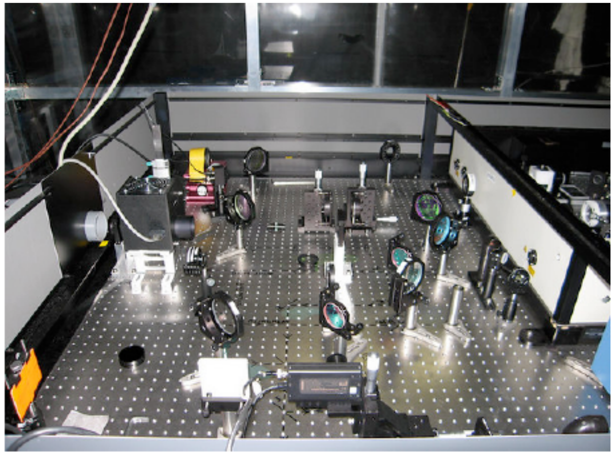
2007:

Closed-loop FB

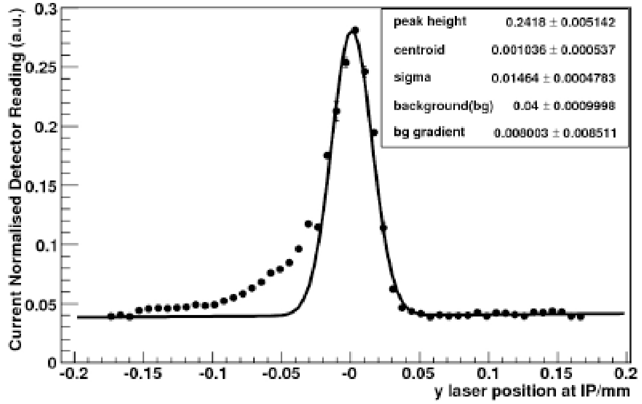
EXT Laserwire

- Installed chamber, transport optics and focusing optics
- Refined Compton experiment electronics
  - Readout system
  - Laser RF locking electronics
- Collisions observed and electron beam profiles measured
- Plans
  - f#2 lens (being tested in Oxford now)
  - Chamber mover system design
  - Interaction point wire scanner design
  - Laser “upgrade” for better transverse mode quality
  - Move towards 1 micron scanner





< June 2006



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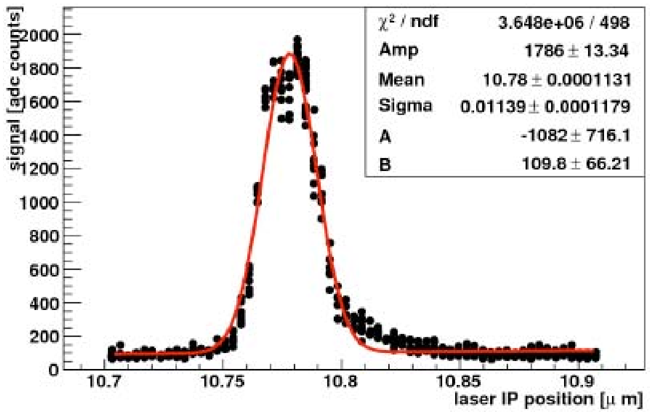
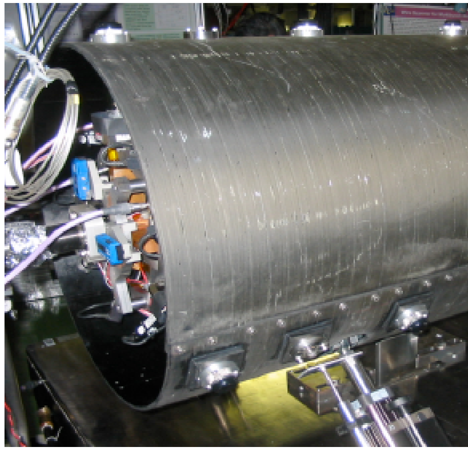


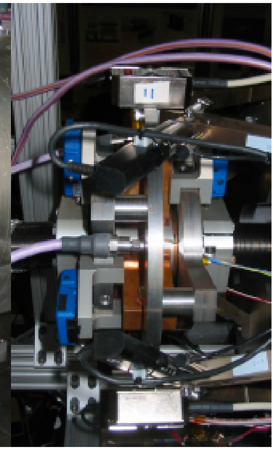
σ from wire ~4 μm; σ from laserwire waist scan ~11.4 μm → laser waist ~10 μm nanoBPM

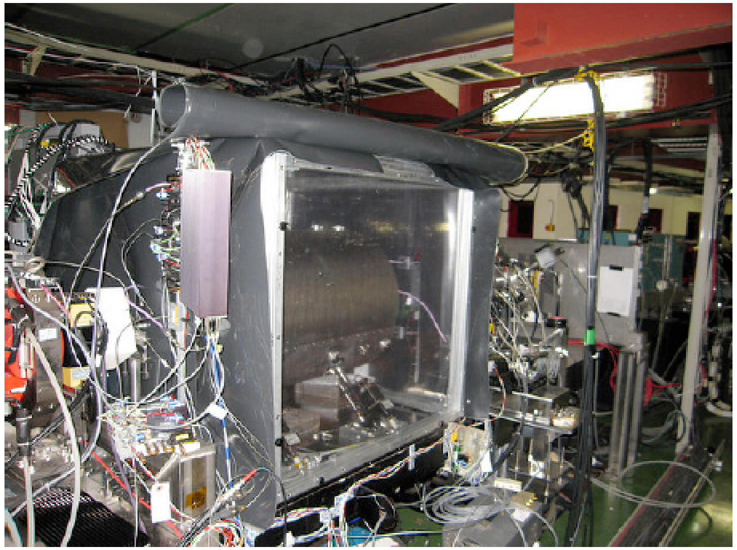
Hardware improvements (beam-line)

- Carbon fibre tube(Jan)
  - Totall encloses the LLNL spaceframe structure
  - Zero thermal coefficient of expansion
  - Should improve thermal stability of BPPMs
- Nanogrids (Jan)
  - Precise monitoring of BPM positions relative to the spaceframe
  - Allows a measurement of the rigid body motion of the structure
  - This could be a significant contribution to achievable resolution
- Thermal/Dynamat enclosure

  Thermal → thermal stability; Dynamat → acoustic isolation

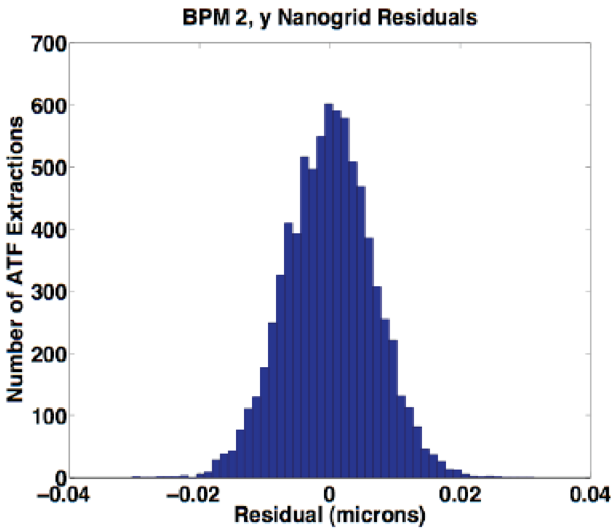


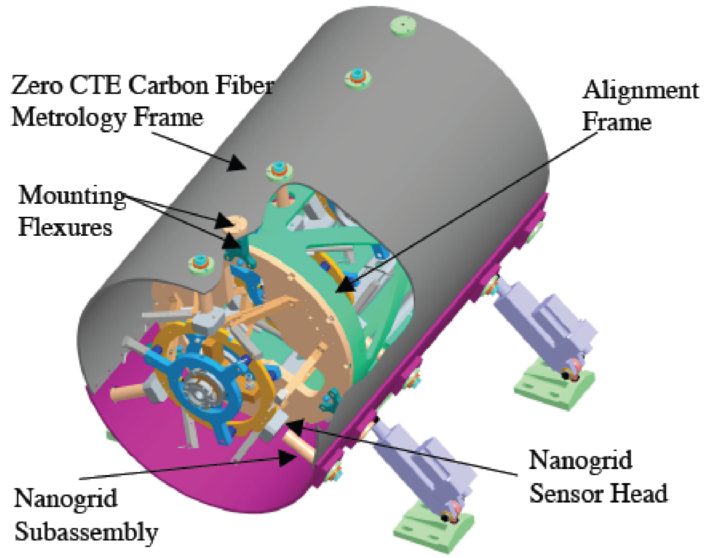




NanoGrid results

- In addition to the carbon tube, a metrology system ('Nanogrids') was added.
  - 2d position measurement, resolution <1nm
  - 3 nanogrids per BPM

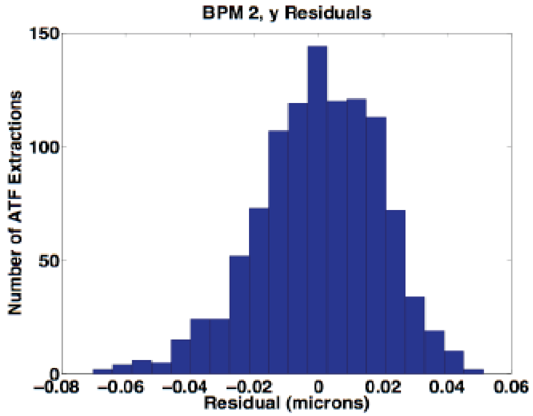


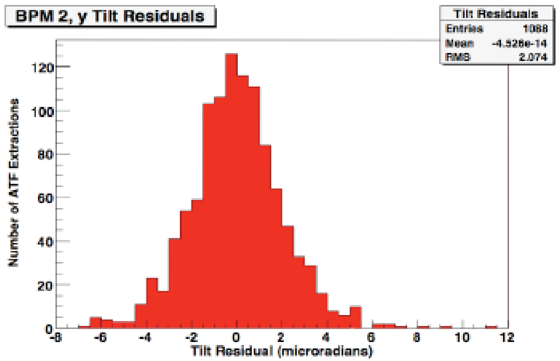


- Using similar regression to the BPM analysis
- Level of rigid body motion
  - 8.4 nm x
  - 4.8 nm y

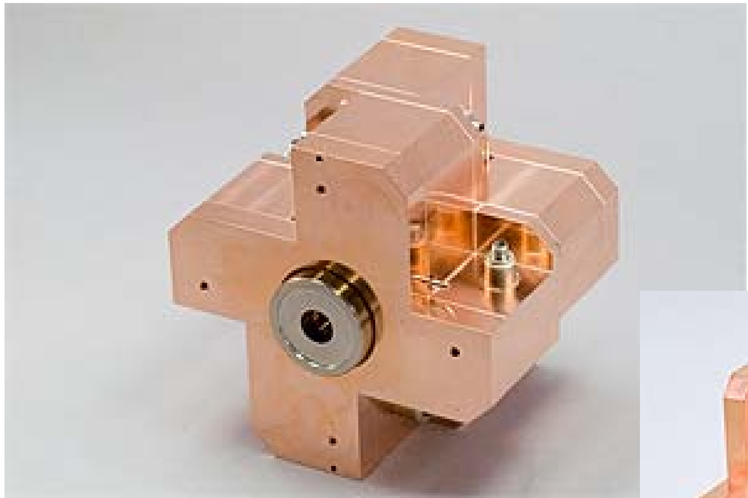
Best measured BPM resolution

- The best recorded resolution April 2006
  - Vertical position : 15.6 nm
  - Vertical tilt : 2.1 μrad
- Position and tilts theoretical consistent
- Both DDC and waveform fitting in good agreement
- From simulations thermal electronics noise not dominant
- Other possible contributions
  - Monopole leakage
  - Cross coupling from x polarization
  - Non-rigid body motion

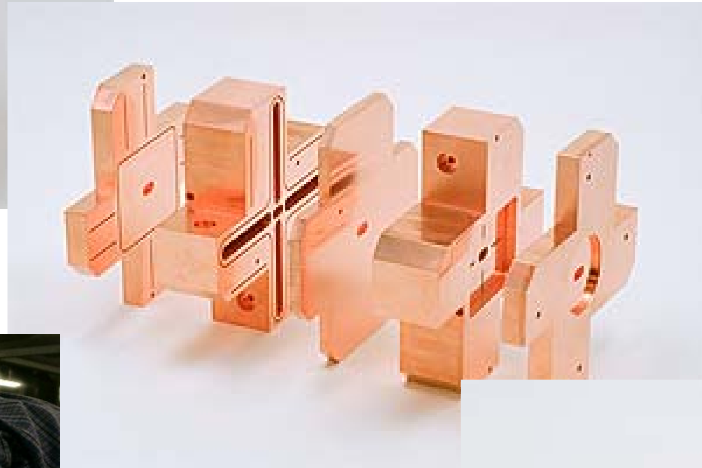




Current status



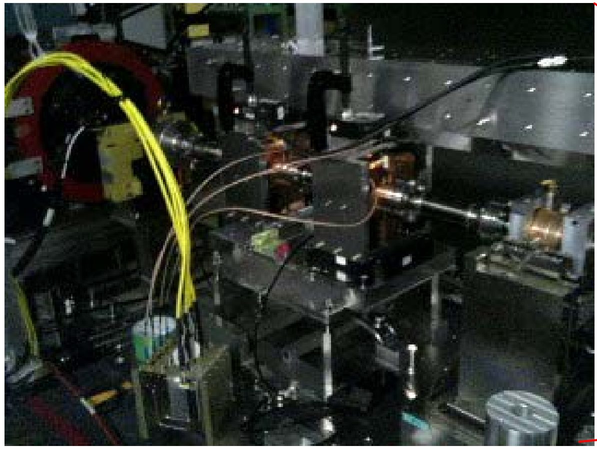
We now have 2 IP-BPMs (4 Cavities, 2 in one module) fabricated.



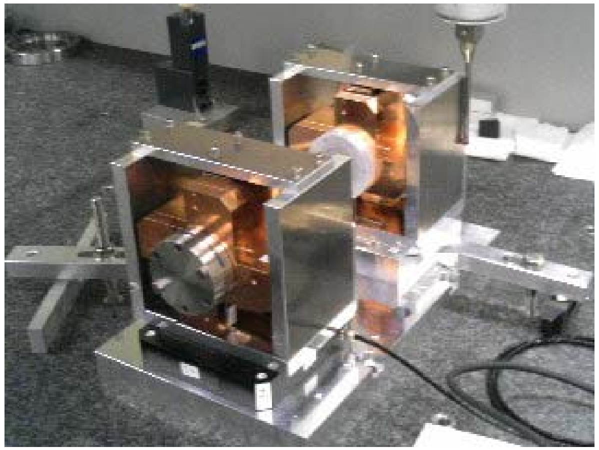
Special thanks to Mr. N. Toge

Current status

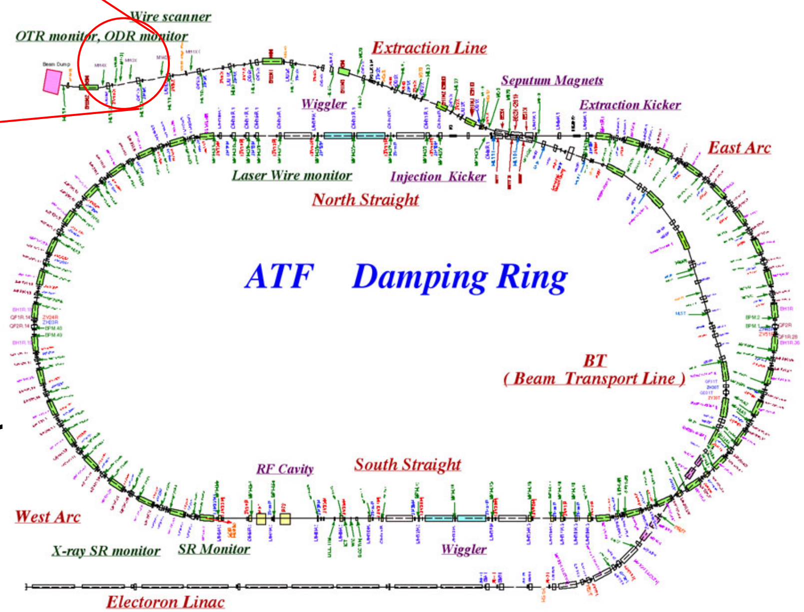
We have carried out beam tests for checking position sensitivity, angle sensitivity, and position resolution.



Now, they are installed in the extraction line of ATF



2 IP-BPMs (4 cavities) with one on a piezo actuator



Position resolution

The resolution turned out to be over 2.7 nm, which show that we have achieved nm position resolution.

The limit of the position resolution

is determined by the thermal noise.

$$V_{TN} = \sqrt{4kTZf_{BW}}$$

$$P_{TN} = kTf_{BW} > -109\ dBm$$

At room temperature, f = 3 MHz

Output amplitude would be,

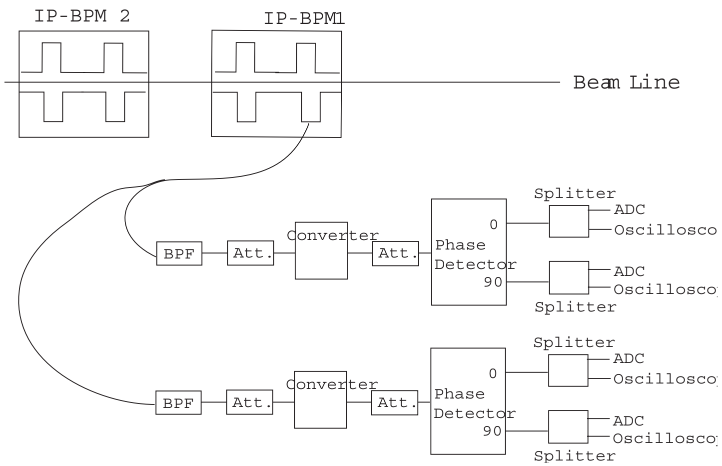
$$V_{out} = \frac{\omega q}{2}\sqrt{\frac{Z}{Q_{ext}}\left(\frac{R}{Q}\right)}\exp\left(-\frac{\omega^2\sigma_z^2}{2c^2}\right)$$

$$P_{out} = -90dBm$$

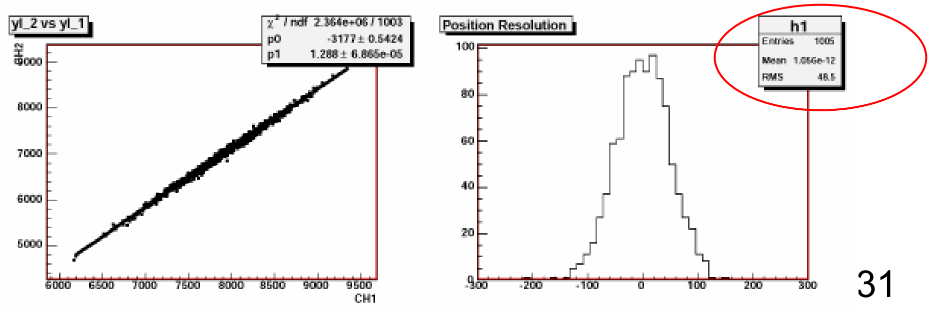
At Z = 50, Bunch Length = 8 mm,

position offset = 1nm

⇒ **nm resolution is possible**



We divided the signal into two and used the same detecting electronic scheme. We can know the thermal noise and the limit of the resolution.



Fast ion instability beam study at ATF

(proposal)

Eckhard Elsen, Guoxing Xia (DESY),
Lanfa Wang, Tor Raubenheimer (SLAC),
Andy Wolski (Cockcroft) and
Junji Urakawa (KEK)

Why study FII at ATF?

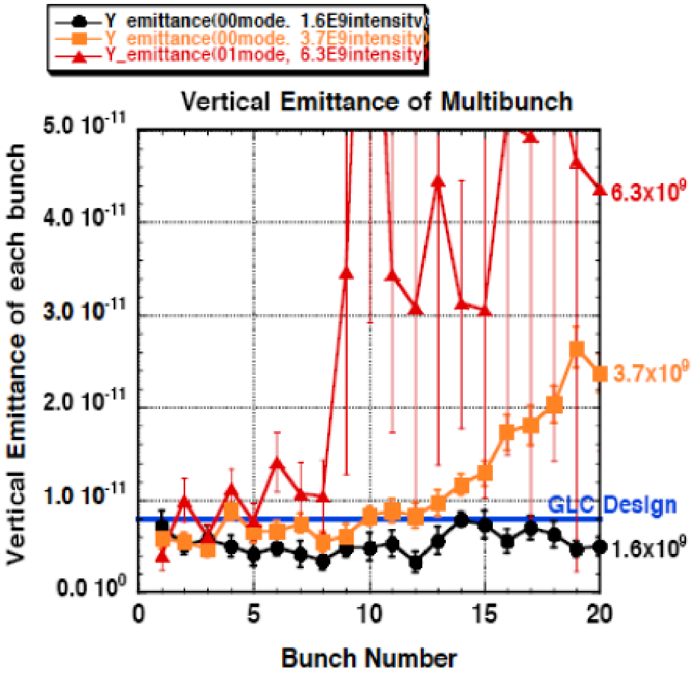
- The ATF beam has small emittance, 4 pm have been achieved (ILC damping ring: 2 pm).
- The accurate turn-by-turn and bunch-by-bunch beam position monitors of ATF can record the beam position for a train of bunches.
- The laser wire can provide precise bunch-by-bunch beam size measurement

Critical issue of FII which can be tested at ATF

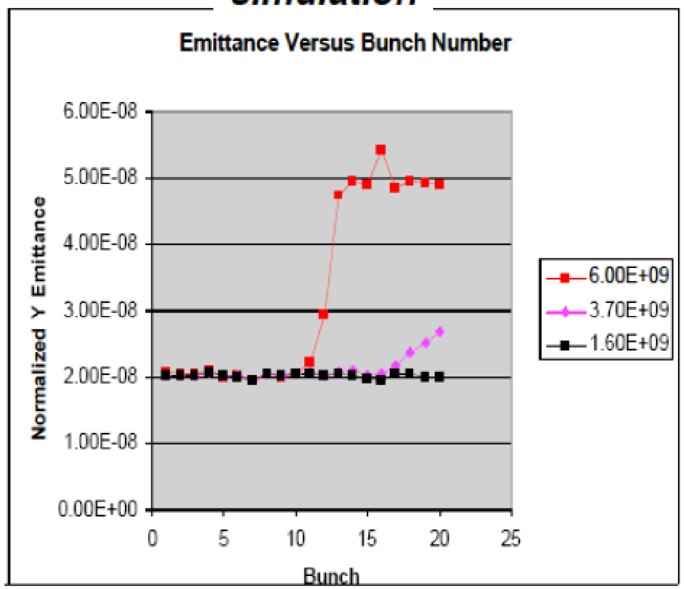
- The main effects of ion cloud include emittance blow-up, fast dipole instability and tune shift. ATF FII experiment can distinguish the two ion effects: beam size blow-up and dipole instability using its very precise diagnostic system.
- The dipole oscillation could be suppressed by a feedback system while there are no efficient ways to suppress the emittance blow-up.

Goals of the experiment

- Distinguish the two ion effects: beam size blow-up and dipole instability.
- Quantify the beam instability growth time, tune shift and vertical emittance growth. Based on the linear model, the growth rate is proportional to the ion density (the related parameters include vacuum pressure, average beam line density, emittance, betatron function and beam fill pattern). Sensitivity to vertical emittance should be largest.
- Quantify the bunch train gap effect
- Beam shaking effect
- Provide detailed data to benchmark simulations with experiment. Relate understanding to other measurements (e.g. ALS, PLS and KEKB).



simulation



Detailed Experiment

- Measurement of vacuum pressure and the main components of gas species.
- Effects of pressure and bunch current, e.g.
  - Vary pressure (5, 10, 20 nTorr) by injecting hydrogen/nitrogen gas or turn off the vacuum pumps
  - Vary beam: 1 train, N= 2, 4, 6, 10, 20×10^9
  - Change optical function to adjust the level of flatness of the beam (Junji's proposal)
    - introduce a vertical dispersion or
    - local coupling of the horizontal and vertical betatron motion
  - Vary train gap
- Repeat with 2 and 3 bunch trains, if possible including length of gaps.
- repeat above with a different emittance
- Beam shaking effect (intermediate plan, 2008?)
- Apply feedback system to damp the beam oscillation; study its performance