



Report of the 5th and 6th Meetings of the ATF Technical Board

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and the University of Liverpool Department of Physics.

*ATF International Collaboration Board,
Chicago, 18 November 2008*

ATF Technical Board

<http://atf.kek.jp/collab/ap/meetings/TB-SGC/TB-SGC-meeting.php>

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Nobu Toge (KEK)
Tomoyuki Sanuki (U. Tohoku)
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Eun-San Kim (KNU)

* *Joint Chairs*

5th Meeting:

21 December, 2007

KEK

6th Meeting:

11-12 June, 2008

WebEx

From the Report of the 6th Meeting of the ATF TB:

"ATF2 installation is proceeding to schedule. The magnets and power supplies (including cables, water cooling, magnet movers) are in place, though the magnets have not yet been surveyed. Radiation shielding and the beam dump have also been installed. Installation of diagnostics (Shintake beam-size monitor, and laser wire monitor) is in progress.

Following shut-down of the ATF at the end of the last run period (end of May), modification of the ATF extraction line has begun. Magnets and supports have been removed; re-installation and relocation of components will begin soon. First beam should be delivered to ATF2 towards the end of October 2008.

The progress being made with ATF2 is impressive, especially considering the funding issues affecting some of the collaborators."

Research Activities (Reported at ATF TB5/6)

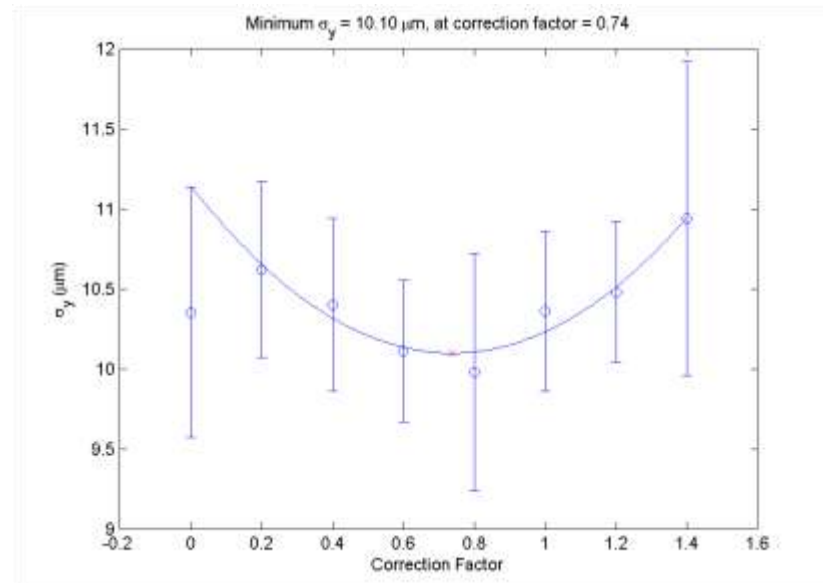
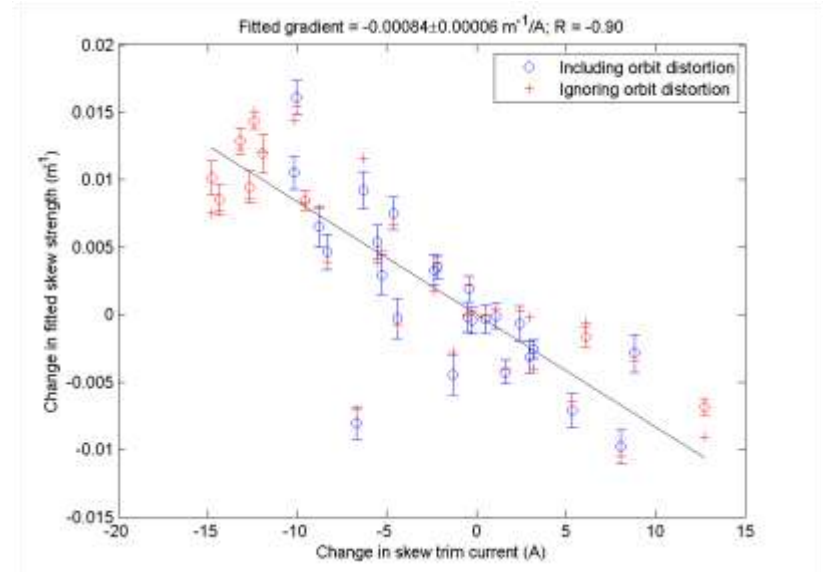
| Activity | Reported by |
|---|-----------------------------|
| Damping ring emittance studies | A. Wolski (CI/U. Liverpool) |
| Damping ring BPM upgrade | M. Wendt (FNAL) |
| Fast extraction kicker | T. Naito (KEK) |
| Extraction line emittance studies | P. Bambade (LAL) |
| Extraction line laser wire | S. Boogert (RHUL) |
| FONT4 | P. Burrows (U. Oxford) |
| Libera BPM studies | N. Terunuma (KEK) |
| Fast ion instability | |
| Compton scattering from DR laser cavity | |
| Collimator damage tests | |
| Cold cavity BPM R&D | |

Damping Ring Emittance Studies (KEK, CI, SLAC)

- **Goal:**
 - To achieve reliable operation of the ATF damping ring with vertical emittance below 5 pm.
- **Present status:**
 - Although 4.5 pm vertical emittance was achieved in 2004, recently the vertical emittance has been around 20 pm.
 - A renewed effort is being made to correct the optics, using beam-based alignment, beta function measurement (using quadrupole strength variation), turn-by-turn data (from Echotek BPMs), and orbit response matrix analysis.
- **Future plans:**
 - Continue systematic approach to tuning the optics and correcting the vertical dispersion and betatron coupling.
 - Upgrade of BPM system should greatly assist in this effort, and provide potential for a vertical emittance of around 2 pm (matching the ILC damping rings specification).

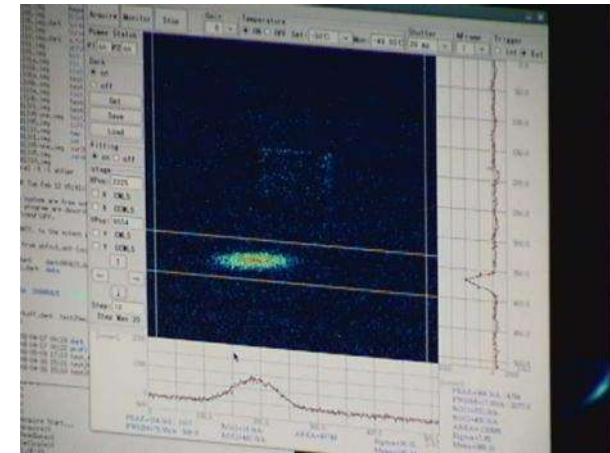
Damping Ring Emittance Studies

- Tuning studies include application of beam-based alignment (to determine BPM-quad offsets); orbit and dispersion correction; and coupling correction.
- Orbit response matrix (ORM) analysis appears capable of identifying changes in skew quad strengths (top right)...
- ...but applying coupling correction based on ORM analysis appears to have little benefit (bottom right).



Remote Participation in ATF Machine Studies

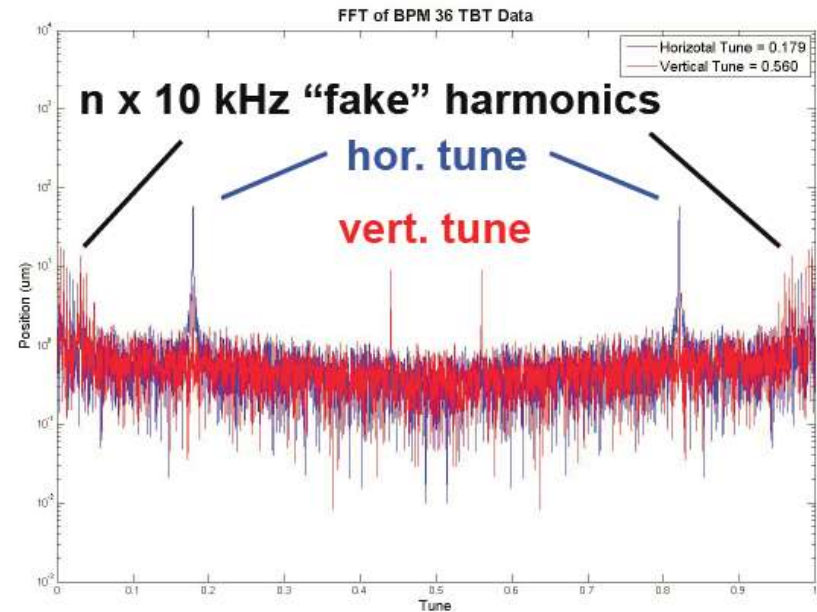
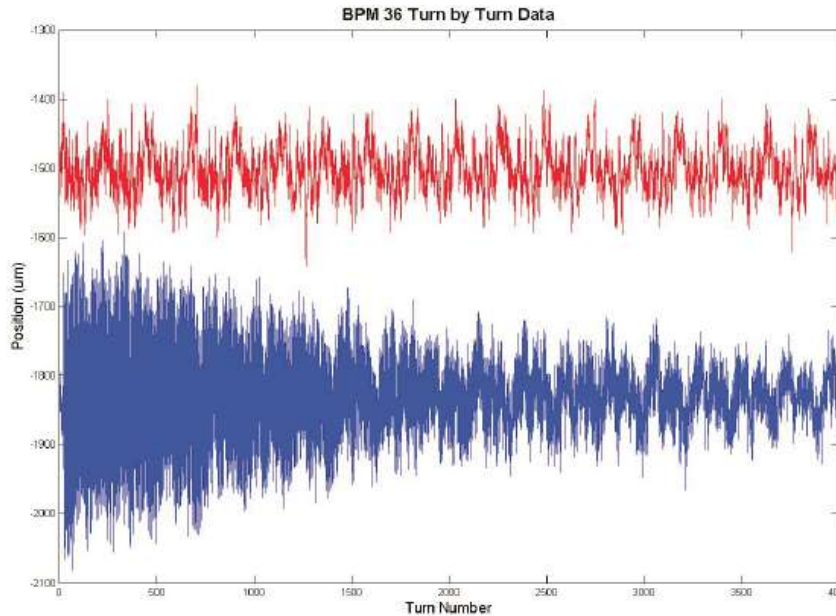
Effective remote participation in machine studies is made possible by use of Control Room Web Cam and Skype.



Damping Ring BPM Upgrade (FNAL)

- **Goal:**
 - to provide the BPM performance needed to achieve a vertical emittance of 2 pm.
- **Present status:**
 - 20 BPMs have been equipped with Echotek digital receivers.
 - Tests show narrowband resolution < 800 nm (around 200 nm with filtering).
 - Measurements in broadband (turn-by-turn) mode used to measure the beta functions at the locations of the BPMs.
 - One BPM (no. 56) equipped with prototype calibration and control system, allowing precise gain characterisation.
- **Future plans:**
 - Resolve issues associated with electromagnetic interference (causing spurious signals at harmonics of 10 kHz).
 - Continue installation of digital receiver modules (to bring total number of Echotek BPMs to 48).

Damping Ring BPM Upgrade



- Turn-by-Turn data BPM #36 (pinger: On)
- Identifying hor. and vert. tune lines (387 kHz, 1.212 MHz).
- Observed short time, broadband TBT resolution: few μm !
- Observation of “fake” harmonics at $n \times 10$ kHz (not f_s), due to power supply EMI in the analog downconverter unit!

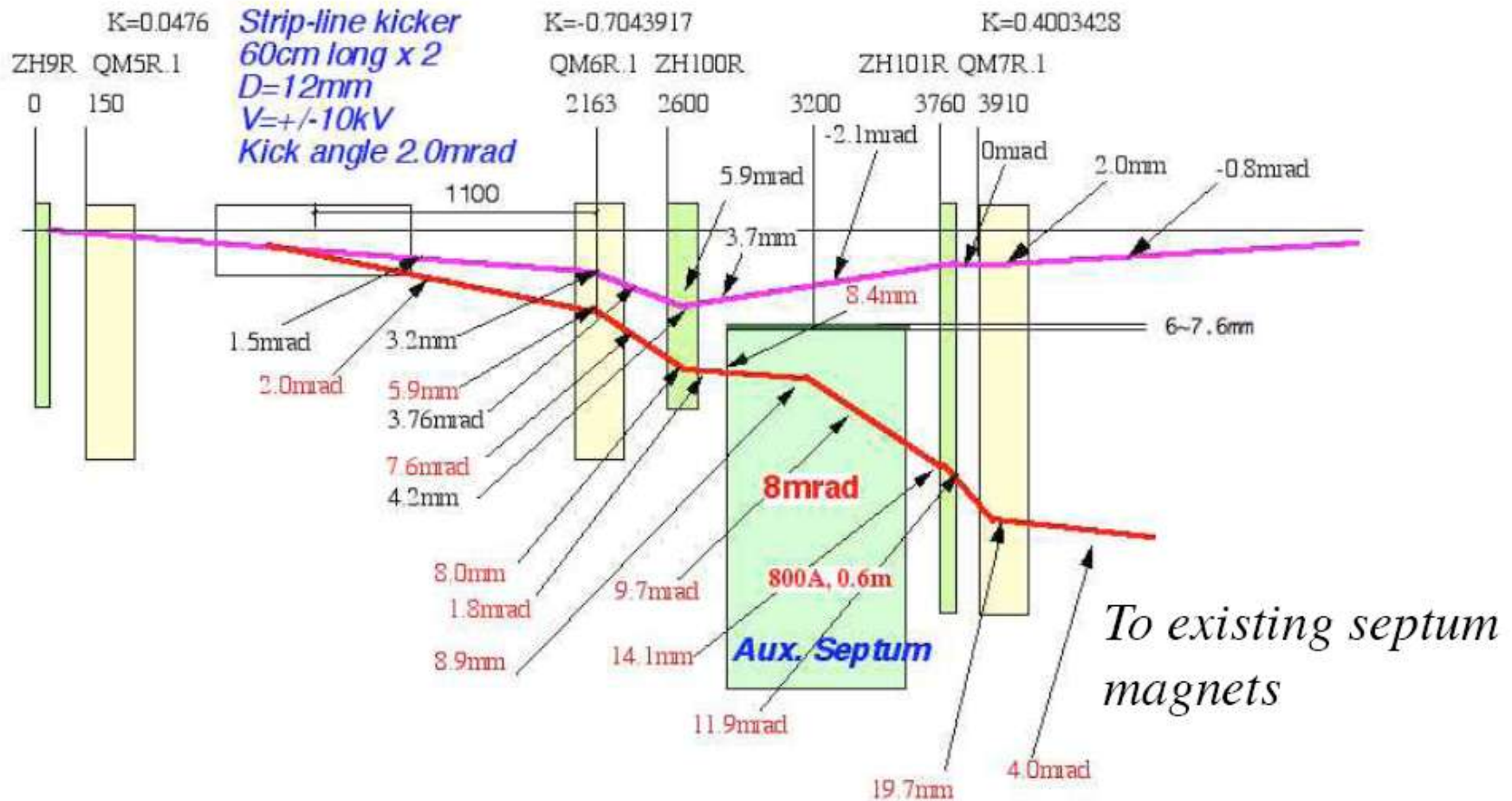
M. Wendt (FNAL)

Fast Extraction Kicker (KEK)

- **Goals:**
 - To provide a system capable of extracting individual bunches from the ATF damping ring, giving ILC-like time structure in ATF2.
 - To prototype fast injection/extraction kicker systems for ILC damping rings.
- **Present status:**
 - Results from pulser tests are promising (rise/fall times, amplitude...)
 - Other components (stripline kicker chamber, septum, pulse train generator) are being fabricated.
 - “Slow” closed orbit bump (used to reduce required amplitude from fast kickers) has been tested successfully.
- **Future plans:**
 - Complete fabrication and installation of extraction components.
 - Perform comprehensive tests (rise/fall times, amplitude, pulse rate, reliability) and operate extraction systems for ATF2.

Fast Extraction Kicker

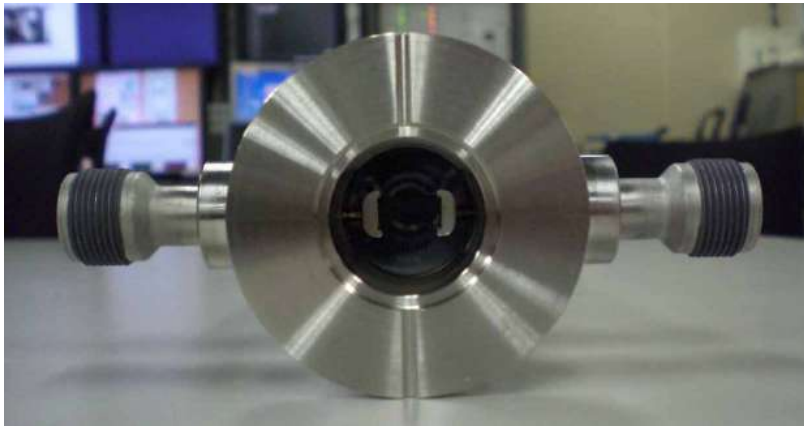
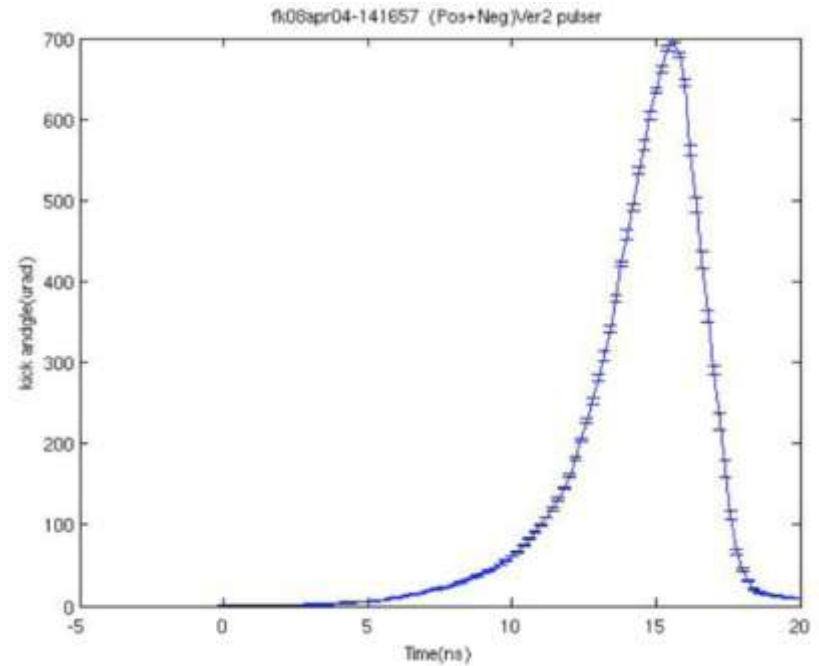
Beam extraction orbit by using Strip-line Kicker



T. Naito (KEK)

Fast Extraction Kicker

- Fast (FID) pulsers now achieving close to 10 kV peak output, with rise time around 2 ns.
- Strip line kickers have been manufactured and show good impedance characteristics.



T. Naito (KEK)

Fast Extraction Kicker: Schedule

| | |
|--|---------------|
| Local closed orbit bump test | January 2008 |
| 10 kV fast pulser test | March 2008 |
| Fabrication of auxiliary septum | October 2008 |
| Fabrication of strip-line electrodes | November 2008 |
| Installation of strip-lines and septum | December 2008 |
| Extraction tests | January 2009 |

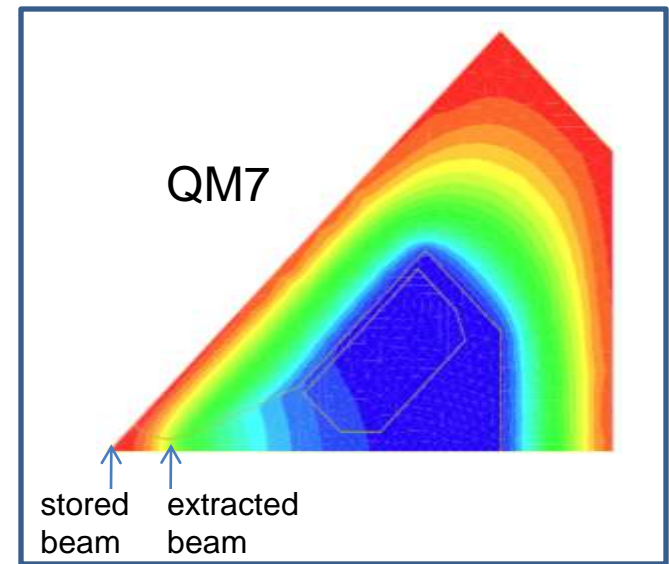
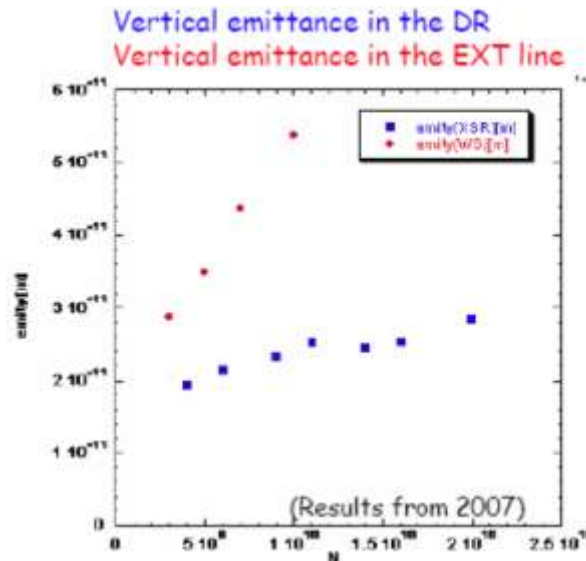
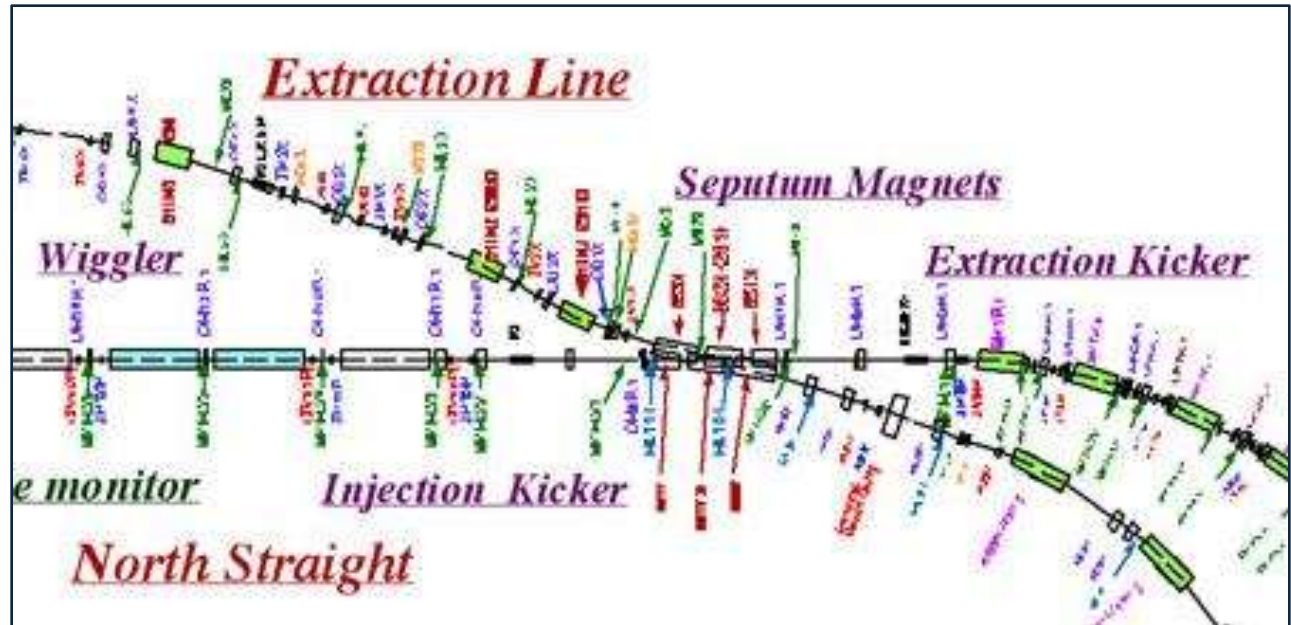
Extraction Line Emittance Studies (LAL *et al*)

- **Goal:**
 - To understand and correct emittance growth observed in bunches extracted from the ATF damping ring.
- **Present status:**
 - Emittance growth in extraction from ATF DR has been observed for some time, but a renewed effort to identify and correct the cause is motivated by the need for ultra-low emittance in ATF2.
 - A number of potential causes of emittance growth have been explored in recent experimental and simulation studies (e.g. poor off-axis field quality in QM6 and QM7 magnets).
- **Future plans:**
 - Continue systematic investigation (using modelling and experimental data) to determine the cause of the emittance growth.
 - Improved extraction-line diagnostics in ATF2 should provide some help.

Extraction Line Emittance Studies

Extracted beam passes off-axis by 22 mm in QM7.

Poor off-axis beam quality may make some contribution to the emittance growth, but seems unlikely to provide a full explanation.



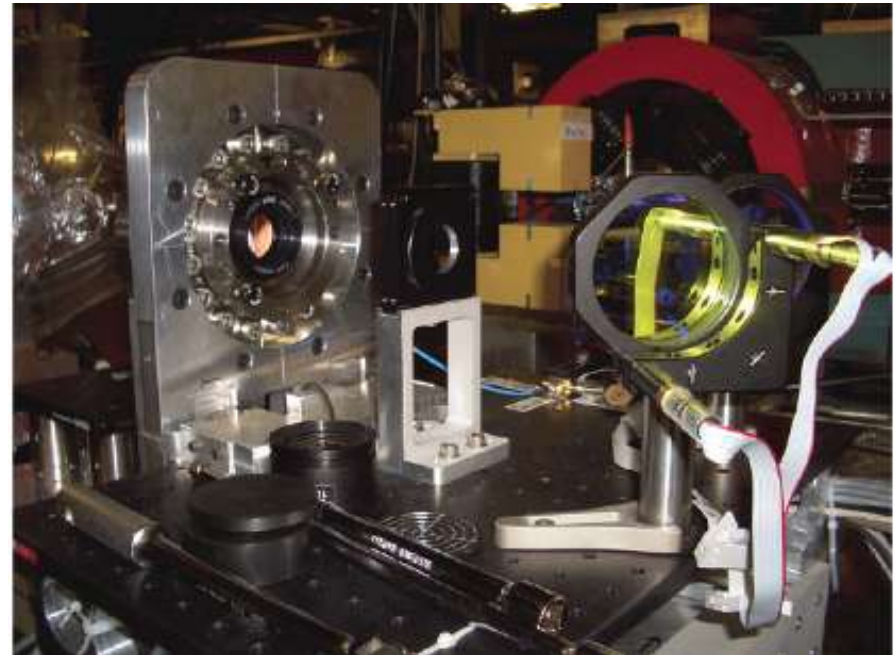
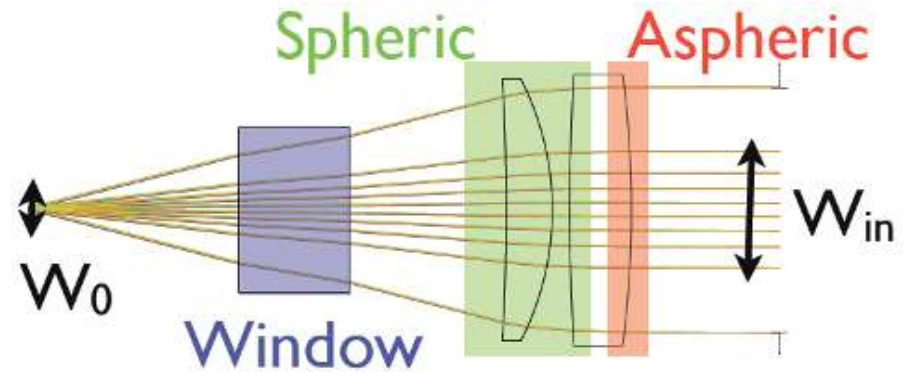
Extraction Line Laser Wire (RHUL, U. Oxford)

- **Goal:**
 - To develop a non-invasive beam size diagnostic with single-shot resolution of order $1\ \mu\text{m}$, for application in ILC.
- **Present status:**
 - System was installed in 2007, and initial tests proved promising.
 - Various hardware upgrades and improvements were made in 2008, including a custom F/2 lens, and sub-micron mover for the chamber.
 - A minimum beam size of $3.7\ \mu\text{m}$ has been measured: this is consistent with expected resolution (based on present performance of lens and laser) of around $3.4\ \mu\text{m}$.
- **Future plans:**
 - Improve laser performance, to reduce the overall resolution limit to $< 2\ \mu\text{m}$.

Extraction Line Laser Wire

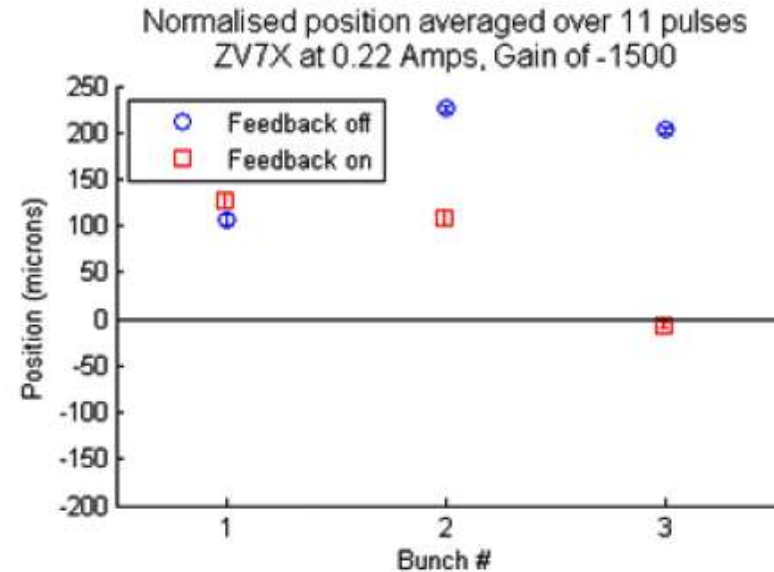
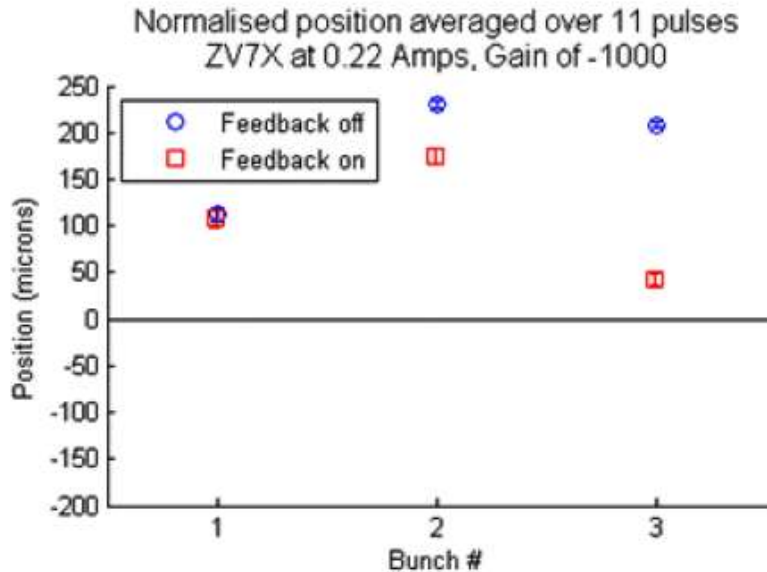
Commercial lens was replaced by a custom design in 2008.

This has allowed the resolution of the beam size measurement to be reduced from $7.8 \mu\text{m}$ to $3.7 \mu\text{m}$.



- Goal:
 - To develop and demonstrate a digital bunch-by-bunch feedback system, with total latency around 120 ns, suitable for ILC BDS.
- Present status:
 - Tests of BPMs show resolution $< 5 \mu\text{m}$; $1 \mu\text{m}$ may be achievable.
 - Two amplifiers with necessary specifications have been manufactured.
 - $\pm 15 \text{ A}$ into 50Ω load; 35 ns rise time; 10 μs pulse; 10 Hz rep rate.
 - Some tests have been performed, demonstrating 140 ns latency, (close to 130 ns expected) despite poor reliability of amplifiers.
- Future plans:
 - Fully test present system and understand characteristics.
 - Resolve reliability problems with amplifiers.
 - Install a dedicated FONT system in ATF2.

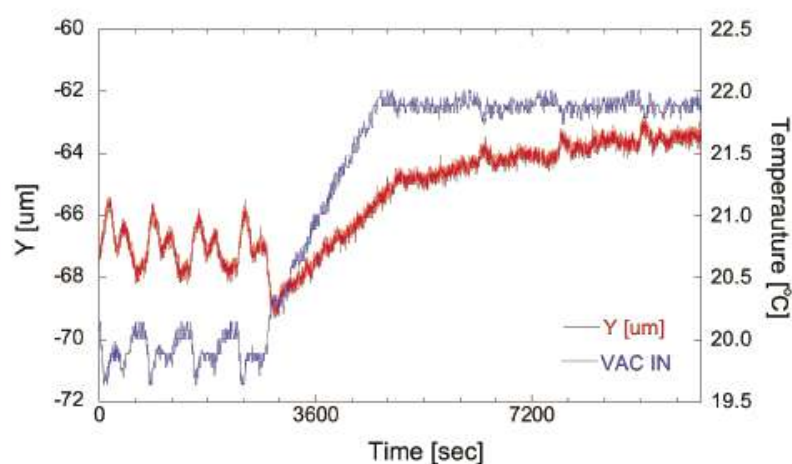
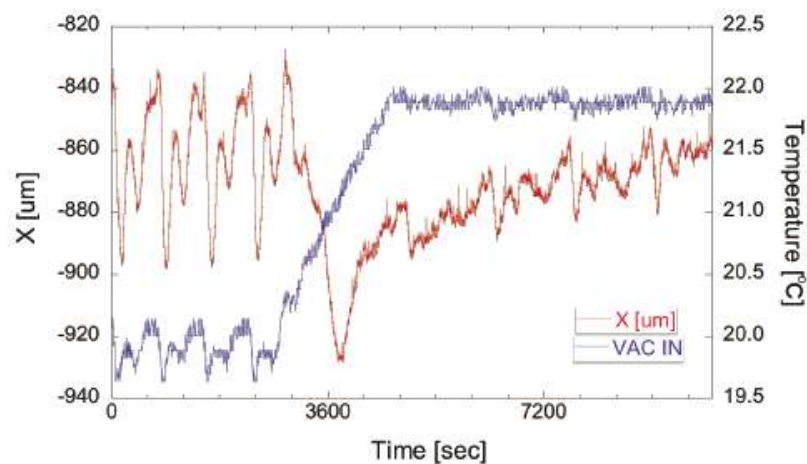
Example results from May 2008 (with 140 ns latency):



Note systematic bunch-to-bunch position variation.

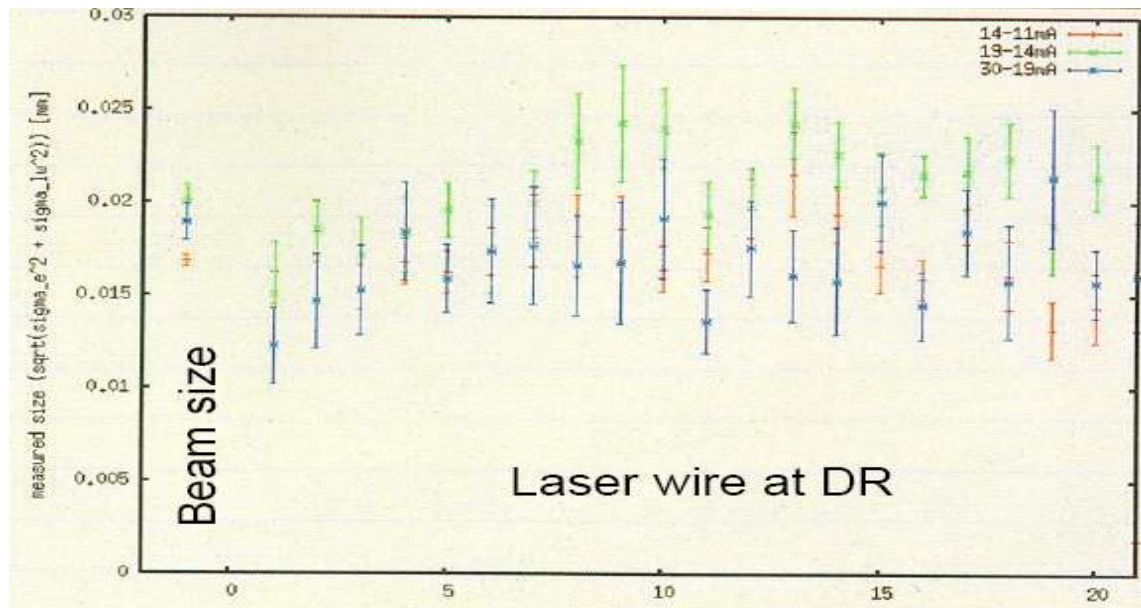
Libera BPM System (KEK)

- Data from Libera digital BPM readouts show that orbit drift in the damping ring (over timescales of order an hour) are correlated with variation in vacuum cooling water temperature.
- Orbit sensitivity to temperature is around $60 \mu\text{m}/0.5^\circ\text{C}$ horizontally, and around $2 \mu\text{m}/0.5^\circ\text{C}$ vertically.
- Recent attempts to stabilise the water temperature have had some effect; work is on-going.



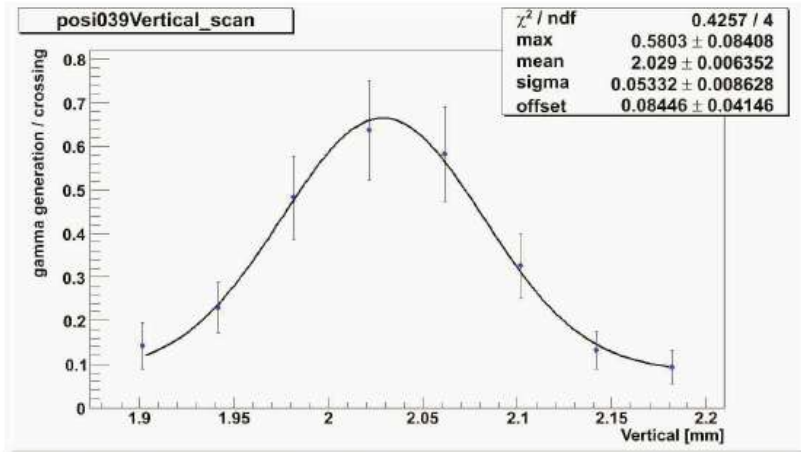
Fast Ion Instability (KEK, DESY)

- Chamber to allow controlled gas injection was installed and tested towards the end of 2007.
- Experiments to try and observe FII were performed in February 2008.
- Vertical emittance is too large at present to allow any observable effects from fast ion instability.

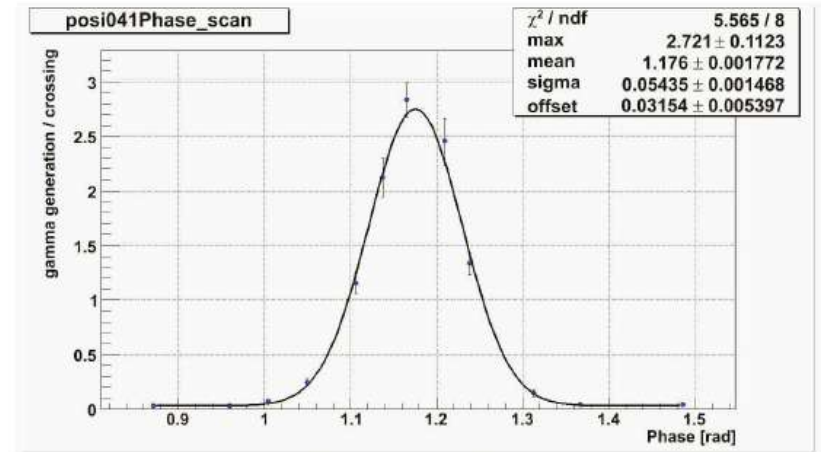


Compton Scattering from DR Laser Cavity (KEK)

- First gamma-ray signal was detected in January 2008.
- A number of tests have been carried out, including position and timing scans, and effects of feedbacks (cavity length, and PLL).
- In single-bunch mode, photon rate is as expected (from CAIN).
- In multi-bunch mode, photon rate is about seven times smaller than expected: this remains to be investigated.



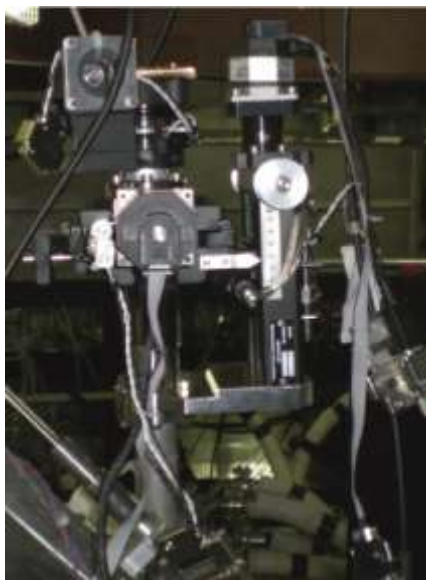
Collision Point Scan in V-direction



Timing Scan (PLL closed)

Collimator Damage Tests (U. Birmingham)

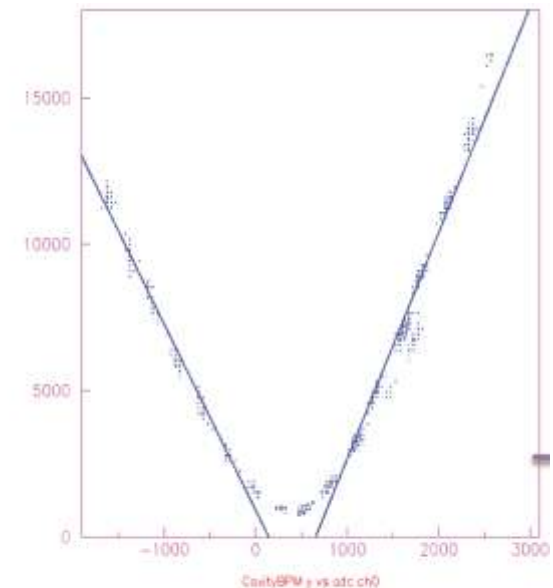
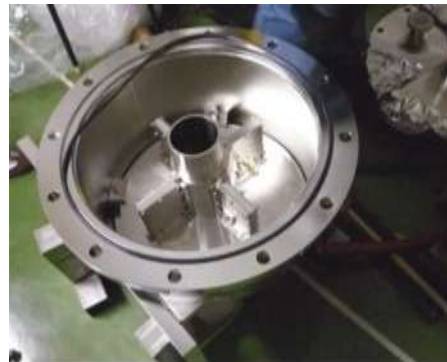
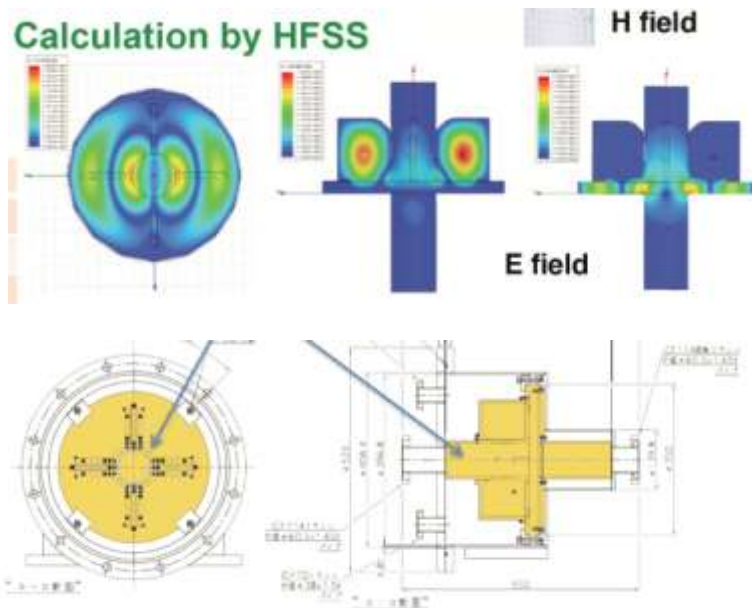
- Goal is to validate Fluka/Ansys simulations for single-bunch impacts on test samples.
- Tests performed in Spring 2008; results under analysis.
- Experiments will be performed at ATF2 to measure shock waves in the samples from multiple bunches with ILC-like bunch spacing.



11 mm

Cold Cavity BPM (KNU/Tohokugakuin/KEK)

- Goal is to develop a high-performance ($< 1 \mu\text{m}$) cold cavity BPM for use in the ILC main linac.
- A cold model has been installed at the end of the ATF linac, where two existing strip-line BPMs can be used to characterise its performance.
- Initial results indicate a resolution of around $0.2 \mu\text{m}$ (at a bunch population of 10^{10}), though the data reveal some unexpected features.



ML BPM Y output (ADC counts) vs. beam Y position [μm] by stripline BPMs

R&D Proposals (1): OTR/ODR Monitors in Extraction Line

- Proposal presented at TB5 by P. Karataev.
- Goals:
 - To install OTR and ODR monitors in the extraction line, to provide beam size diagnostics complementary to the laser wire.
 - To demonstrate resolution of order $1\ \mu\text{m}$ using OTR and ODR.
 - To provide fast beam size diagnostics with dynamic range more than $50\ \mu\text{m}$, to allow rapid tuning of the laser wire.
- Feasibility:
 - The plans are feasible based on experience with OTR and ODR.
 - The diagnostics will be fully integrated into the extraction line laser wire.
- Recommendation:
 - The proposed system will allow further development of OTR and ODR techniques, and provide useful diagnostics for ATF2.
 - **The ATF Technical Board supports the proposal.**

R&D Proposals (2): Ultra-Low β^* in ATF2

- Proposal presented at TB6 by R. Tomas, on behalf of a collaboration including CERN, CI, IHEP, KEK, LAL and SLAC.
- Goals:
 - To reduce β_y^* in ATF2 from 0.1 mm (nominal) to 0.05 mm (reducing beam size at focus from 37 nm to 26 nm).
 - To demonstrate feasibility of high-chromaticity final focus optics in CLIC (at 500 GeV) or ILC pushed beyond nominal parameters.
 - To learn how tuning difficulty scales with beam size.
- Feasibility:
 - Simulation studies indicate 26 nm spot size is feasible at ATF2.
 - Some additional hardware may be required for the more ambitious parts of the experiment.
 - 26 nm is within the dynamic range of the Shintake monitor.
- Recommendation:
 - The goals are within the mission of ATF2, are technically feasible, and consistent (on a timescale of 2010/11) with the ATF2 schedule.
 - **The ATF Technical Board strongly supports the proposal.**

R&D Proposals (3): Future Laser Facility at ATF2

- Proposal presented at TB6 by T. Tajima, JAEA
- Goal:
 - To develop a facility for colliding photons from a high-power laser with the highly-focused electron beam at ATF2, to be used for a range of physics studies.
- Recommendation:
 - The presentation given to the ATF Technical Board did not constitute a formal proposal, but provided much interesting and useful information for further consideration.
 - The purpose of a high-power laser facility may be outside the core mission of ATF/ATF2. Consideration should be given to how such a facility would fit with the existing planned programme.
 - A formal proposal should indicate how ATF/ATF2 provides a uniquely suitable facility for the experiments to be performed.

General Remarks

- There continues to be an exciting, diverse range of R&D activities based on the ATF. Good progress is being made in many areas.
- The continued progress with ATF2 is particularly encouraging, and impressive.
- There have been a number of significant improvements in the damping ring instrumentation in the last year:
 - X-ray synchrotron radiation monitor allows rapid measurement of the beam size in the damping ring, with resolution of a few μm .
 - A significant source of “slow” orbit drift has been identified (variation in vacuum cooling water temperature), and is being addressed.
 - 20 BPMs in the damping ring have been equipped with Echotek digital signal processing units, and show good performance.
- Large (20 pm) vertical emittance in the damping ring continues to be a concern. There is now a systematic effort being made to address this.
- **The Technical Board would like to express their appreciation for the hard work of all the researchers; but particularly to the team at KEK for their continued hard work that has enabled an extremely successful collaboration to be maintained in difficult circumstances.**