ATF2 future R&D

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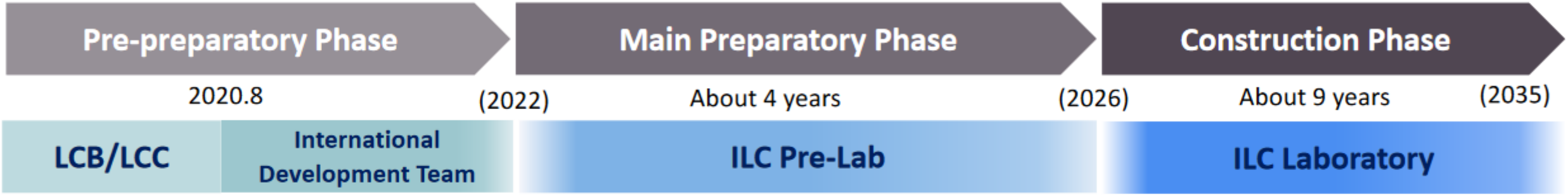
High Energy Accelerator Research Organization (KEK)

ATF Review Meeting – September 29th 2020

ILC expected timeline and ATF/ATF2

In August 2020, ICFA established the International Development Team (IDT) for ILC as a successor of the Linear Collider Board (LCB) and Linear Collider Collaboration (LCC). IDT will define the structure of the ILC Pre-Lab.



ATF/ATF2 activities

education/training of young researchers

Technical preparations for ILC

Beam test bench for ILC

Utilization of ATF beam for other researches and developments

Remaining studies planned for the next few years

Study of 2nd order aberrations and corrections

- Systematic measurement of the main higher order aberrations
- Evaluation of the energy bandwidth
- IP beam size tuning for the beam optics with stronger aberrations.

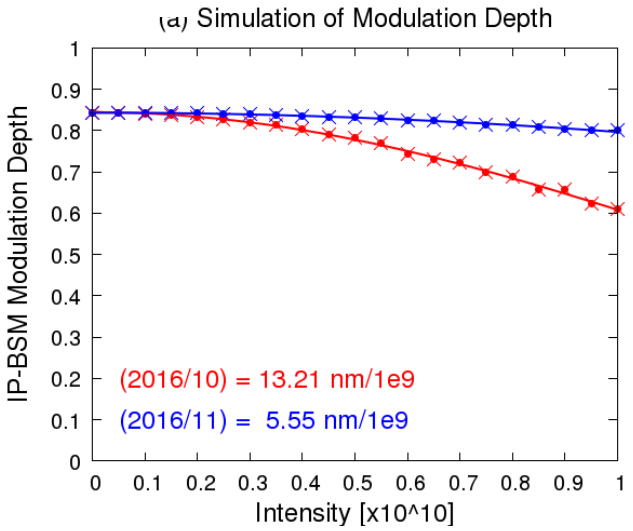
Study of intensity dependence (wakefield)

- Quantitative understanding of the wakefield source for ATF2 beamline
- Investigation of the intensity dependence source other than that for wakefield

Systematic studies for the beam size tuning and the intensity dependence reduction with FONT FB

Intensity dependence for overall ATF2 beamline

Intensity dependence simulation for dynamic intensity dependence

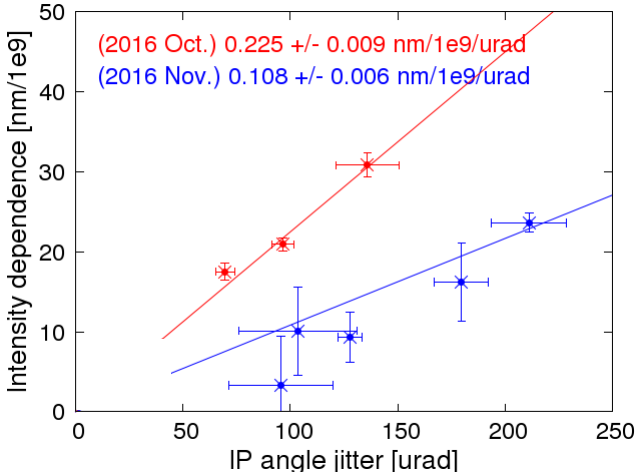


Dynamic intensity dependence was evaluated by changing the bunch charge for nominal ATF2 optics.

The IP angle jitter was assumed to be 30% of IP divergence.

	2016 October	2016 November
Intensity Dep.	$13.21\ \mathrm{nm}/10^9$	$5.55\ \mathrm{nm}/10^9$
IP angle jitter	$104\ \mu\mathrm{rad}$	$104\ \mu\mathrm{rad}$
Normalized	$0.127\ \mathrm{nm}/10^9/\mu\mathrm{rad}$	$0.053\ \mathrm{nm}/10^9/\mu\mathrm{rad}$

Intensity dependence measurement by dynamic intensity dependence



The measured intensity dependence was roughly twice as strong as that for the simulation for the wakefield model for overall ATF2 beamline.

(see Sec.4.2.2 of the report in details.)

We will investigate the discrepancy at next few years operation.

Beam studies for ILC preparatory phase

Stability study

- Investigation of the slow orbit drift
- Permanent GM monitoring to evaluate the vibrations sources

Beam monitor study

- Stabilizing the IPBSM system
- Stabilizing the cavity BPM readout

Beam tuning technique study

- Dispersion feedback in the ATF extraction line

Technical preparations at ATF/ATF2 in the ILC preparatory phase

- ***Long term stability of beam size and orbit at the ATF2 interaction point***
- ***Long term stability of fast injection and extraction systems.***

The importance of these items were mentioned in

- the revised KEK-ILCaction plan in 2018
- the Recommendation on ILC Implementation by the KEK International WG in 2019

These items were also pointed out as specific technical issue by

- the ILC Advisory Panel of MEXT
- the ILC committee in the Science Council of Japan (SCJ)

Upgrade of ATF2 for ILC technical preparations (ATF3)

ATF3 would hence provide the opportunity to attract additional resources from overseas collaborating institutes to deliver the program described above in a modular and sensibly time-ordered fashion.

Overhaul and upgrade of the existing ATF2 beamline to model more accurately the energy-scaled ILC final-focus system.

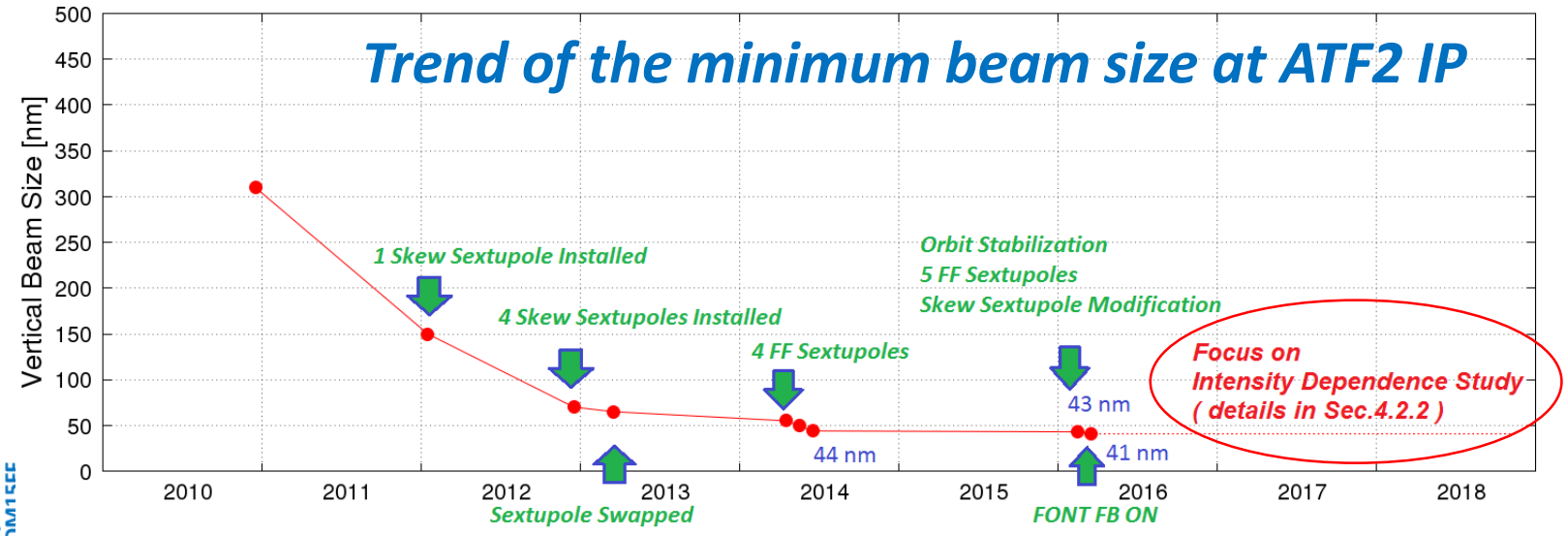
- Some magnets with poor magnetic field qualities will be replaced.
- Wakefield sources will be removed and replaced.
- ILC-style diagnostic devices (BPMs etc.) will be installed.
- IP BSM laser will be upgraded to provide for stable, long-term operations.

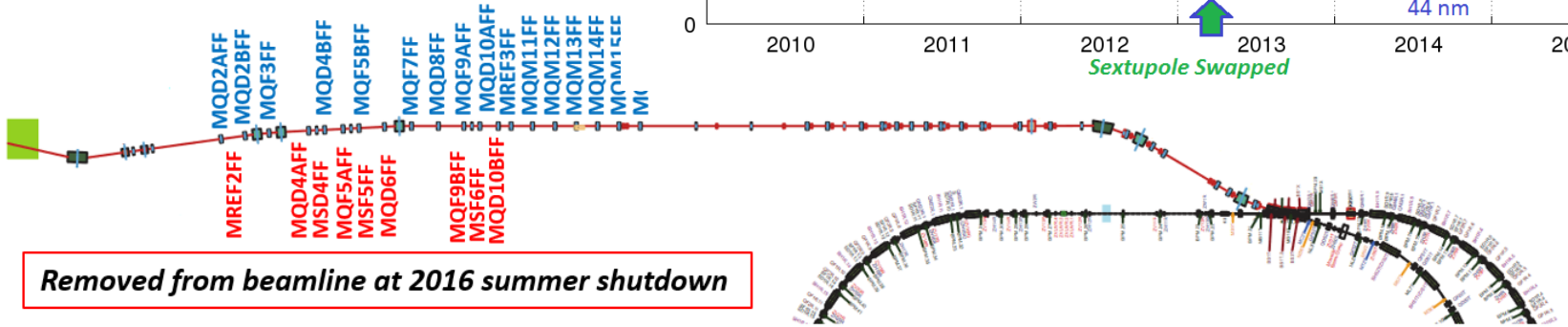
Beam studies in ILC construction period

- SC final-focus QD0/QF1 magnet system could be installed at the ATF3 IP.

Overhaul and upgrade of existing ATF2 beamline

Some of cavity BPMs were removed for intensity dependence study at 2016 summer shutdown.



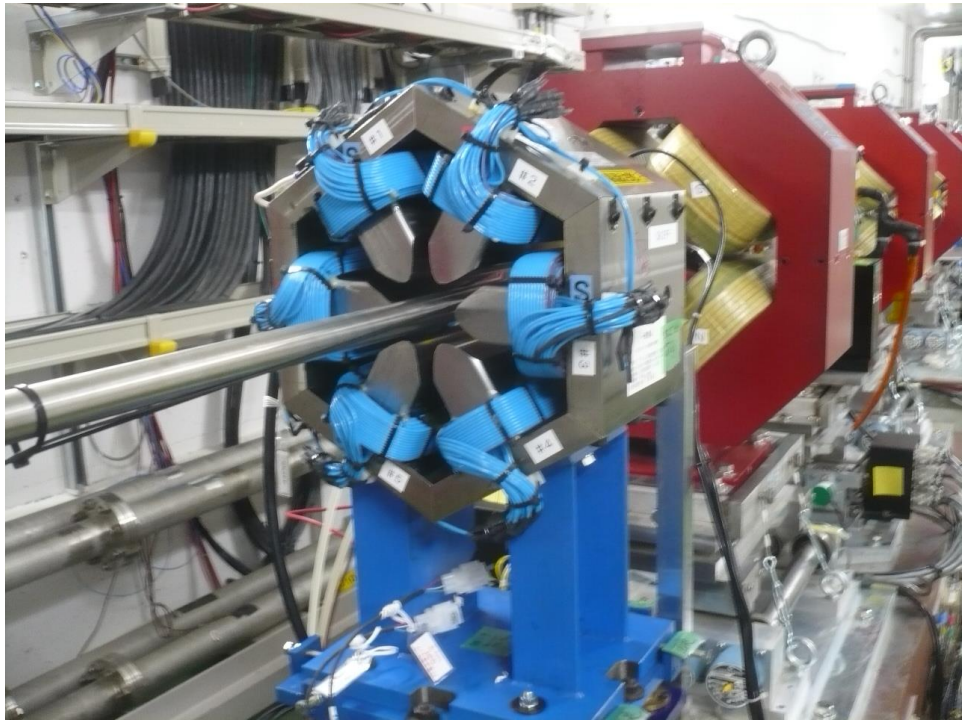


- *Cavity BPMs will be relocated to the original ILC like setting in order to perform the same tuning procedure of ILC.*
- *Then, the wakefield effects will be corrected for the stronger wakefield condition than ILC.*

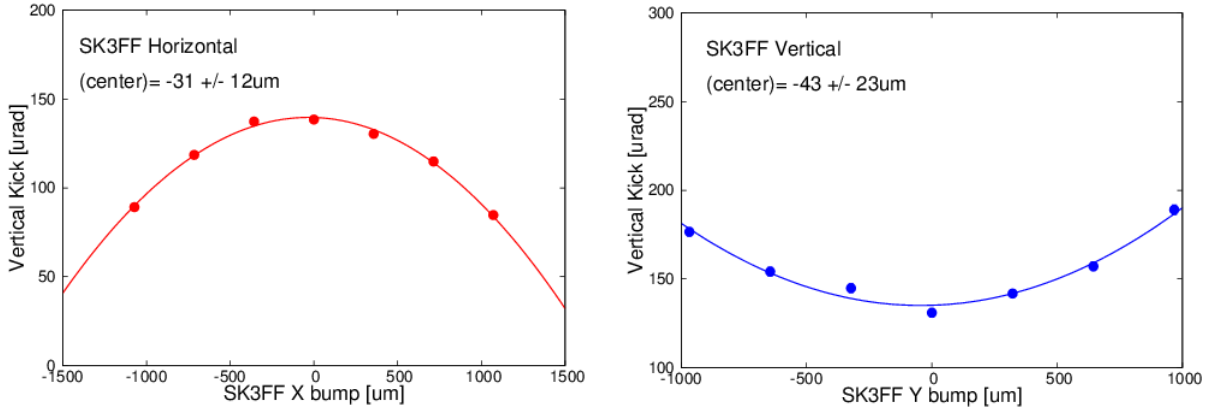
Overhaul and upgrade of the existing ATF2 beamline (Skew sextupoles)

In order to perform same tuning procedure of ILC,

- Skew sextupole magnets will be remade to be those with good field qualities.
- The magnets will be located on magnet movers.



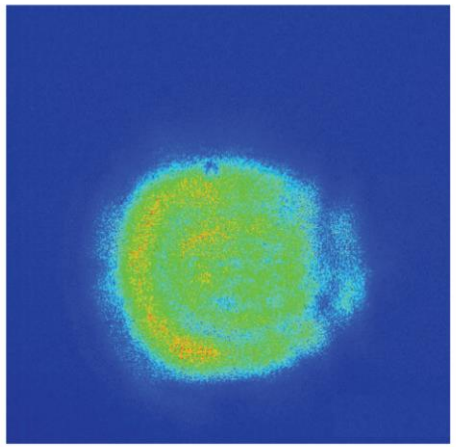
Results of BBA for SK3FF at 2016/02/03

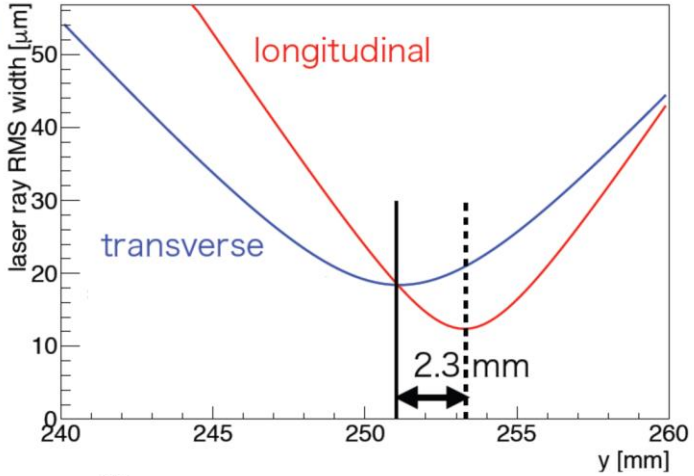


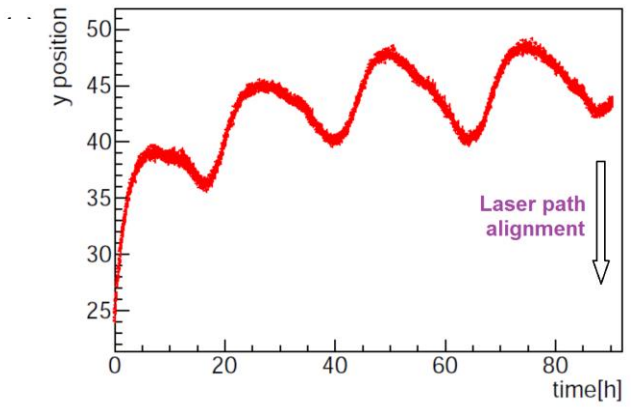
When the beam trajectory is adjusted to be no quadrupole field, the beam orbit is kicked by the residual dipole field component.

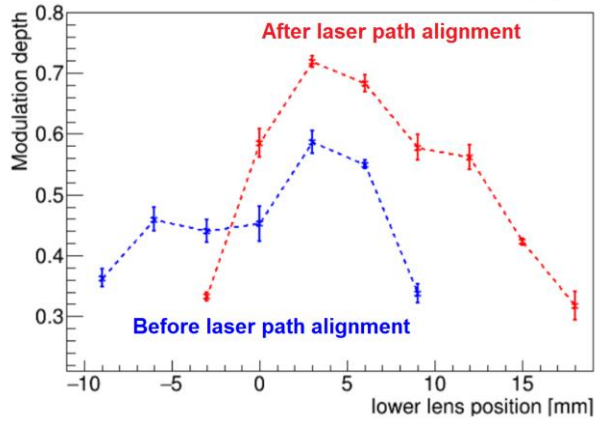
Overhaul and upgrade of the existing ATF2 beamline (IP-BSM Laser)

In order to continue more accurate beam size measurement for a long period of time, we would like to replace it with a single-mode laser that can realize an ideal laser profile.









The profile of the IPBSM laser currently used in ATF2 is not good.

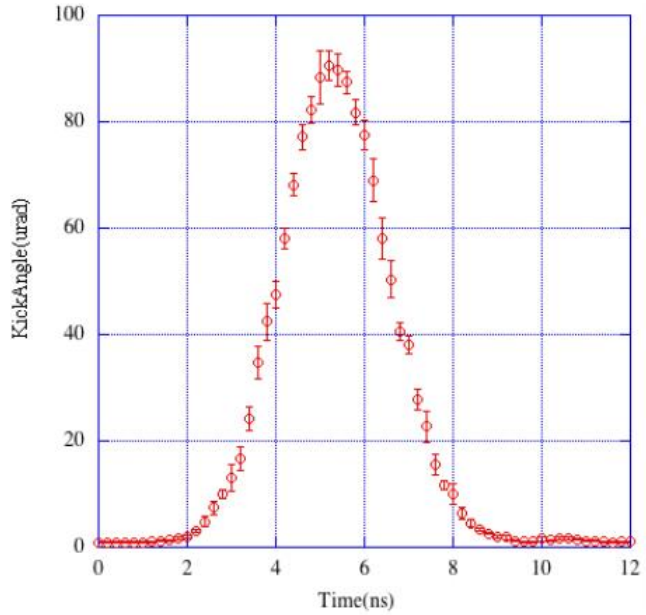
The beam size measured with this monitor affects to the laser position drift.

(see Sec.4.2.1.2 in detail).

Long-term stability of the fast kicker system

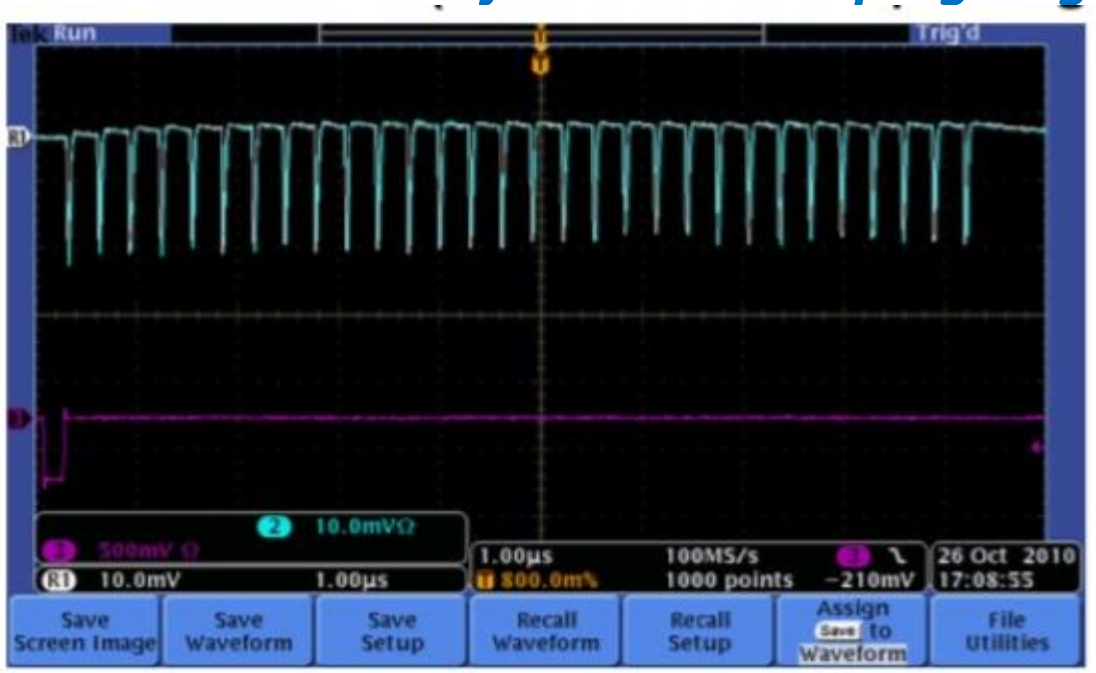
In order to avoid the heating problem from synchrotron radiation in DR, we are planning to install the test stand in the ATF extraction line.

Beam kick as a function of time



(see Sec. 4.4.1 in detail)

Extracted bunches from ATF damping ring



The beam operation test of the fast kicker system was performed in the ATF DR in 2011. The multi-bunch extraction was successfully demonstrated, however the heating problem on the strip-line kicker occurred by the Synchrotron radiation.

Possible use of ATF for ILC preparation other than final focus system

Platform for beam testing and to verify the performance of key ILC components **in the construction phase**

- The best technology should be selected at the time of construction.
- ATF can serve as both a test stand for key accelerator components and a platform for long-term stability tests **with beam**.

For example

- *Superconducting device test bench*
  - *Final doublet*
  - *Crab cavity*
  - *Helical undulator for polarized positron source*
- *Permanent magnet test bench*
- *Polarized electron source test bench*

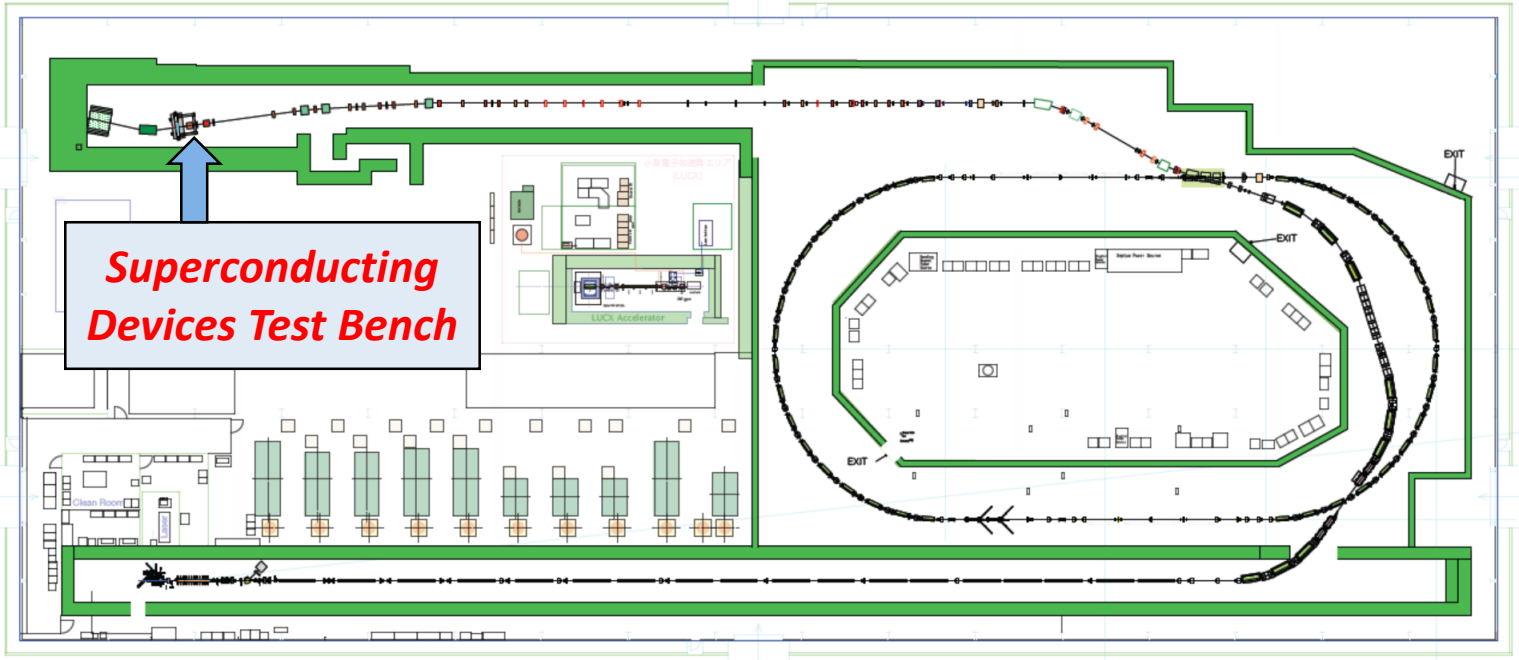
etc.

Superconducting Final doublet test bench

The prototype of final focus magnets will be fabricated to install to ATF2 beamline by using same technology. By using the test bench, we can test the technologies of

- the vibration of the superconducting magnet by Helium flow.
- the multipole field correction **with beam**.

The ILC superconducting final focus magnets were designed by BNL.



Superconducting test bench can be used for …

Crab cavity test bench

*It is very useful experience to fabricate a prototype crab cavities designed by Fermilab (9-cell 3.9 GHz), and **a beam test** using the fabricated cavities at the ATF facility.*

- *The ILC crab cavities are based on the Fermilab design for a 9-cell 3.9 GHz cavity.*
- *3-cell prototype has been manufactured and achieved a gradient of 7.5 MV/m in cold tests.*
- *Proof-of-principle test of a 7-cell 1.5 GHz cavity at the JLab ERL facility has demonstrated the phase control and the feasibility.*

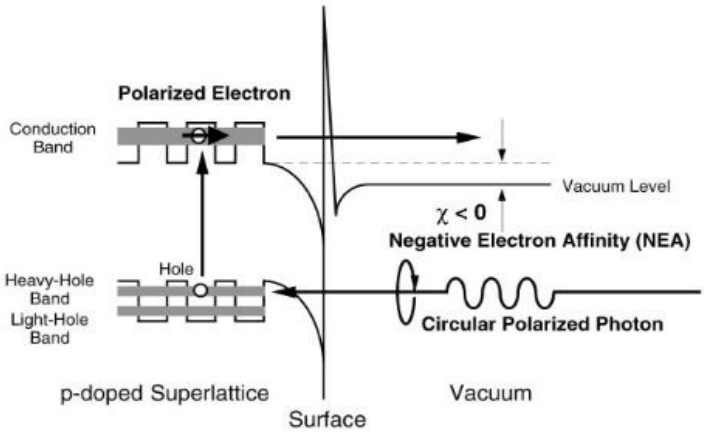
Helical undulator for the polarized positron source test bench

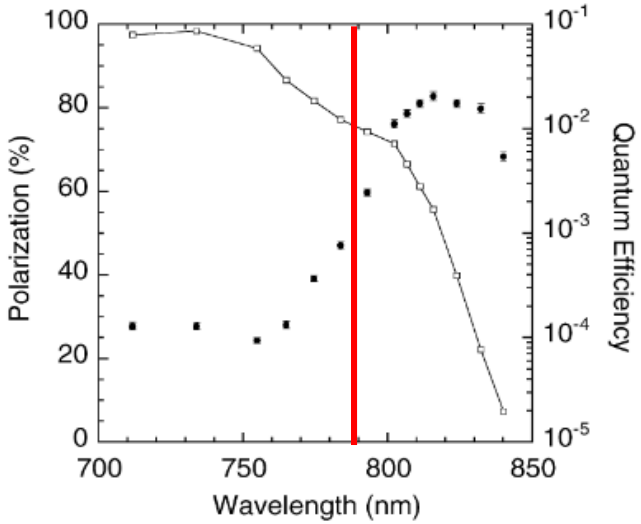
*By making a new magnet at the ATF facility, it is possible to further improve the magnet production technologies and **demonstrate the orbit tuning for the narrow aperture of the undulators**.*

- *Prototype of two helical undulators for ILC polarized positron production were manufactured and tested at Daresbury Laboratory. Both of them achieved the magnetic field strength required for ILC.*
- *The field quality for one of them was poor (but tolerable for the ILC requirement).*

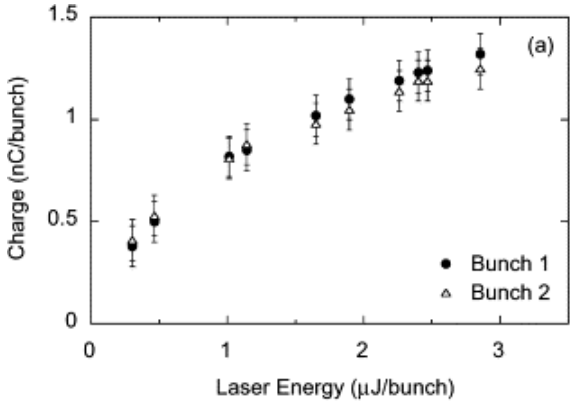
Polarized electron source test bench

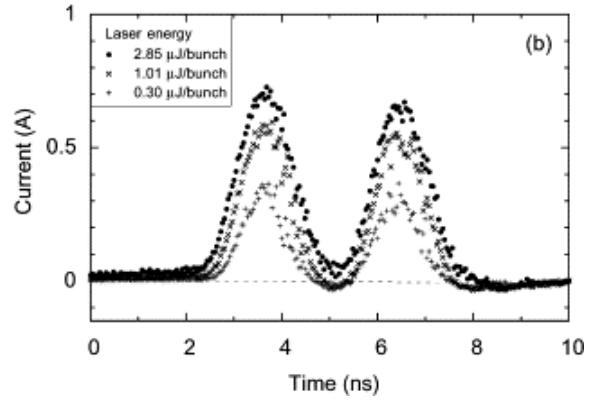
It is useful for the ILC to develop a laser with the ILC bunch structure and to perform a cathode test when a large current of electrons are generated at the beam operation.





Two beam generation by Nagoya Univ. group





In order to satisfy both high quantum efficiency and polarity at the same time, the laser wavelength must be finely controlled. Therefore, the polarized electron gun uses a Ti:Sapphire laser as a laser whose wavelength can be changed.

K. Togawa et al., Nucl. Instr. and Meth. ***A455*** *(2000) 119*

Summary

Beam operation at the ATF for ILC is required for the following three purposes:

- *Continuation of previous research*
- *Technical preparations at ATF/ATF2 in the ILC preparatory phase*
- *Possible use of ATF for ILC preparation other than final focus system*

Sustaining ATF operation from these perspectives is useful for the ILC.

In particular, the last few years of operation are very useful not only to continue the research so far, but also to prepare for the technical preparations to be carried out during the ILC preparation period.

Technical preparation in the preparatory period were mentioned in the revised KEK-ILC action plan in 2018, and the Recommendation on ILC Implementation by the KEK International WG in 2019.

In addition, the ATF beam is considered to play an important role not only during the ILC preparatory period but also during the construction period as a test bench for various elements required for the ILC.