NLC - The Next Linear Collider Project

Accelerator Test Facility at KEK

Linear Collider Damping Ring Prototype

ATF is the only test facility with ~LC emittance
From the SLC to the NLC

(from D. Burke)

- Two Issues…
  - Energy x 10 beyond SLC
  - Luminosity x 10,000 beyond SLC

- Experience basis of NLC/JLC
  - ATF creation of low emittance beams
  - NLCTA X-band technology
  - FFTB manipulate, focus and measure
  - ASSET multi-bunch emittance preservation
  - SLC ....
Linear Collider Damping Rings

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>High current</td>
<td>0.75 A</td>
</tr>
<tr>
<td>Low emittance and coupling</td>
<td>$\varepsilon_y \sim 10\ \text{pm};\ 0.5%\ coupling$</td>
</tr>
<tr>
<td></td>
<td>(SLC $\varepsilon_y \sim 1.3\ \text{nm}$)</td>
</tr>
<tr>
<td>Rapid injection/extraction</td>
<td>120 Hz cycle</td>
</tr>
<tr>
<td>Fast damping</td>
<td>5 ms</td>
</tr>
</tbody>
</table>

• Collective effects:
  – Intra-beam scattering (this talk)
  – Space charge tune shift (TESLA 17 km ‘ring’)
  – Two-stream (fast ion/electron cloud – B factory)
  – Impedance driven (SLC ‘sawtooth’)

ATF is intended to test the above
### Damping ring comparison – design parameters

<table>
<thead>
<tr>
<th></th>
<th>NLC MDR 120Hz</th>
<th>ALS</th>
<th>ATF</th>
<th>SLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>E (GeV)</td>
<td>1.98</td>
<td>1.9</td>
<td>1.28</td>
<td>1.19</td>
</tr>
<tr>
<td>C</td>
<td>299.792 m</td>
<td>196.7 m</td>
<td>138.6 m</td>
<td>35.3 m</td>
</tr>
<tr>
<td>Lattice</td>
<td>36 cell TME</td>
<td>12 cell TBA</td>
<td>36 cell FOBODO</td>
<td>22 FODO</td>
</tr>
<tr>
<td>$\epsilon_{x\ _{eq}}$</td>
<td>0.560 nm rad</td>
<td>5.60 nm rad</td>
<td>1.4 nm rad</td>
<td>18.2 nm rad</td>
</tr>
<tr>
<td>$t_x, t_y, t_z$</td>
<td>4.85, 5.09, 2.61 ms</td>
<td>15, 21, 13.5 ms</td>
<td>12, 17, 11 ms</td>
<td>3.06</td>
</tr>
<tr>
<td>U/turn (bend/ID)</td>
<td>247 keV, 530 keV</td>
<td>250 keV, 20 keV</td>
<td>41.4 keV, 29 keV</td>
<td>93.1 keV</td>
</tr>
<tr>
<td>$\sigma_z / \delta$</td>
<td>3.60 mm / 0.1%</td>
<td>6.00 mm / 0.08%</td>
<td>6 mm / 0.06%</td>
<td>8 mm / 0.07%</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>2.95×10^{-4}</td>
<td>1.62×10^{-3}</td>
<td>2.14×10^{-3}</td>
<td>0.018</td>
</tr>
<tr>
<td>$G_v / \text{acceptance}$</td>
<td>1.07 MV, 1.5%</td>
<td>1.1 MV, 3%</td>
<td>0.3 MV, 1%</td>
<td>0.8 MV, 1%</td>
</tr>
<tr>
<td>Coupling</td>
<td>0.5%</td>
<td>3% (0.5%)</td>
<td>0.6%</td>
<td>~ 10%</td>
</tr>
<tr>
<td>Bunch Charge</td>
<td>0.75×10^{10} / 1.5×10^{10}</td>
<td>0.60×10^{10}</td>
<td>1.0×10^{10}</td>
<td>4×10^{10}</td>
</tr>
<tr>
<td>Lifetime</td>
<td>minutes?</td>
<td>4.6 hours</td>
<td>~5 minutes</td>
<td>10’s of minutes</td>
</tr>
</tbody>
</table>

8/30/01

**ATF at KEK** - Marc Ross/SLAC
ATF studies:

- Single bunch emittance
  - Evidence for intra-beam scattering
  - Correction schemes
- Emittance measurements
- Planned single bunch
- Instrumentation RD at ATF
- Multi bunch

Emittance:

- NLC spec: \( \gamma \varepsilon_x = 3 \times 10^{-6} \) \( \gamma \varepsilon_y = 2 \times 10^{-8} \) m-rad
- ATF achieved: \( \gamma \varepsilon_x = 5 \times 10^{-6} \) \( \gamma \varepsilon_y = 6 \times 10^{-8} \)
- ATF expected: \( \gamma \varepsilon_x = 5 \times 10^{-6} \) \( \gamma \varepsilon_y < 1 \times 10^{-8} \) (0.1% cpl)
- Single bunch; 1.28 GeV; 1e10 ppb (NLC: 1.98 GeV; 8e9)

Minimum theoretically possible emittance \( \rightarrow \) SR opening angle \( \gamma \varepsilon_y \sim 5 \times 10^{-10} \) (0.2 pm for ATF)

What are important emittance issues?
- Ring dispersion / coupling correction
- Intra-beam scattering
- Extraction line optical aberration correction
- Instrumentation
Laserwire
Wire scanners
Energy spread monitor
$\eta = 2.4$ m

Synchrotron radiation monitor

Single bunch:
$I < 3$ mA
(SLC 60 mA)

Damping Ring

1.3 GeV
$1 \times 10^{10}$
1997 ->

Injection Transport Line

KEKの敷地内に運転中のJLCのための試験加速器
Collective effects – single bunch

- Intra-beam scattering
  - Key topic of ATF work
    - Low energy (1.3GeV)
    - poor damping (w/o EM wigglers)
    - excellent extracted beam energy spread diagnostic
  - more studied at proton machines (primary $L$ limit in RHIC)
  - important single bunch emittance driver for NLC
  - no threshold: dependence on bunch volume
- Potential well distortion
- “Microwave” instability
  - serious problem at SLC
    - worse with ‘strong’ but still a problem with ‘weak’
    - definite threshold observed
    - Not expected at ATF
Evidence for IBS – vertical coupling into $\sigma_E$

Sequence:
- Vertical still large – no effect on $x$ and $E$
- Vertical damped – increase in $x$ and $E$
- Minimum at 70ms ($2.5 \tau_{\text{rad}}$)

Simulation consistent when coupling $\Rightarrow$

$\varepsilon_y / \varepsilon_x = 0.006$

Nominal extraction time for NLC DR – IBS growth $< equilibrium$
Damping ring comparison

CLIC Damping ring studies – showing importance of IBS for DR designs

Geometric emittances vs E for LC DR’s (J. Jowett – PAC01)

\[ \varepsilon (\text{m}) \]

- SLC \( x \)
- SLC \( y \)

ATF achieve
NLC main
CLIC 1 TeV

\( 1. \times 10^{-8} \)
\( 1. \times 10^{-9} \)
\( 1. \times 10^{-10} \)
\( 1. \times 10^{-11} \)
\( 1. \times 10^{-12} \)
\( 1. \times 10^{-13} \)

\( E \) (GeV)

\( z, x, y \) emittance vs time – 2 CLIC DR designs (dashed – low I – no IBS)

2 GeV ring (similar to NLC design)

4.6 GeV ring (~2.5 km)
\( \sigma_{E/E} \) measured using extraction line screen

Data from 3 days:
Variation due to tuning & screen monitor performance

- Zero current energy spread ~ 5.5e-4 is close to expected.
Energy spread on/off $v_x=v_y$
coupling resonance – showing IBS effect

on resonance

$\sigma_z$ [10^{-4}]

$I$ [mA]

$V_c=300$ kV

off resonance

$\sigma_z$ [10^{-4}]

$I$ [mA]

$V_c=300$ kV
Emittance vs intensity

Wire scanner and ring laserwire results

- Extraction line wire scanner emittance (red)
- Ring – internal – laserwire (y only) (blue)
- Simulation uses zero current \( \varepsilon_x \)

- NLC target

- 30 pm
- 2.5 nm

- Vertical emittance (m-rad)
- Horizontal emittance (m-rad)

- NLC target

- \( \varepsilon_y \)
- \( \varepsilon_x \)

- Extraction line wire scanner emittance (red)
- Ring – internal – laserwire (y only) (blue)
- Simulation uses zero current \( \varepsilon_x \)
- $e_y$ inconsistent with expectations
- ?
  - IBS theory/simulations
  - coupling/emittance dilution in extraction line
  - measurement related errors

Negative correlation between $\varepsilon_y$ and $\delta$ shows that $\eta$ is not dominant in $\varepsilon_y$ measurement.
Intra-beam scattering - $\varepsilon$ growth mechanism

Beam phase space temperatures in rest frame: 7000:35:1 ($x, y, z$)

- energy flows into $z$ from $x$ – diffusion
- kicks back into $x$ where $\eta \neq 0$
  - $\eta \neq 0$: off-energy particles are not on equilibrium trajectory following energy exchange
  - effective transverse kick
  - emittance growth
- if $\eta = 0$; no harm done
- effect on $\varepsilon_y$?

- Similar to synchrotron radiation
  - growth rate = damping rate at equilibrium
  - collisions involve energy exchange between particles
  - but: SR from bends only; IBS everywhere
  - also: IBS interaction with other collective effects
Intra-beam scattering – theory

- Small transfer approximation of Touschek lifetime
  - Limitation in SR sources
- Bjorken & Mtingwa + Piwinski + LeDuff
  - \( x-y \) coupling and microwave related \( \sigma_z \) distortion not included in most simulations
  - Interaction with other instabilities
- Factor 2 discrepancy for proton machines
  - Depending on model
  - (RHIC, p_bar, V/LHC with ions)
- Tail generation – (should be important for downstream users)
  - Cut-off parameter introduced
  - Reduces computed ‘rms’ emittance by 30%
**IBS – relative growth rate**

\[ H = \left[ \eta^2 + (\beta \eta' + \alpha \eta)^2 \right] / \beta \] \textit{dispersion invariant}

\[ \frac{\varepsilon_{y0}}{\varepsilon_{x0}} = \frac{\langle H_y \rangle_B}{\langle H_x \rangle_B} \frac{J_x}{J_y} \]

Zero current emittance – determined by SR in bends

\[ \frac{d\varepsilon_y}{d\varepsilon_x} = \frac{\langle H_y \rangle}{\langle H_x \rangle} \frac{J_x}{J_y} \]

Emittance growth from IBS – determined by dispersion throughout

\[ \langle H_y \rangle_B \approx \langle H_y \rangle \]

for emittance generated through residual \( \eta \) as opposed to residual coupling

Divide and assume that there is nothing special about \( \eta_y \) in the bends

\[
\frac{\langle H_x \rangle_{bends}}{\langle H_x \rangle} = \frac{(\varepsilon_y - \varepsilon_{y0}) / \varepsilon_{y0}}{(\varepsilon_x - \varepsilon_{x0}) / \varepsilon_{x0}}
\] \textit{(Tor & Kubo)}

8/30/01
Dispersion invariant – $H$ – for ATF and NLC design

\[
\frac{\langle H \rangle_{bends}}{\langle H \rangle} = 1.6 @ ATF
\]

\[
\frac{\langle H \rangle_{bends}}{\langle H \rangle} = 0.64 @ NLC
\]

$H$ at ATF

$H$ of NLC arc cell

NLC DR – A. Wolski (LBL)
Emittance results

- $\varepsilon_{y0}$ extrapolation is poor
- Observed energy spread & horizontal emittance growth indicates a 2 - 3 x smaller vertical emittance than observed
- Growth ratio shows a similar factor
- Measurements made 4/00 to 6/01

Table of emittance measurements: (e-9/e-11 $x/y$, not normalized)

<table>
<thead>
<tr>
<th>Date</th>
<th>e_x0</th>
<th>e_x</th>
<th>e_y0</th>
<th>e_y</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>wires 4/00</td>
<td>1</td>
<td>1.85</td>
<td>1</td>
<td>3</td>
<td>2.35</td>
</tr>
<tr>
<td>Dec-00</td>
<td>1.1</td>
<td>2.2</td>
<td>1.7</td>
<td>4</td>
<td>1.35</td>
</tr>
<tr>
<td>Feb-01</td>
<td>1.1</td>
<td>2.2</td>
<td>0.7</td>
<td>2.8</td>
<td>3.00</td>
</tr>
<tr>
<td>Apr-01</td>
<td>1</td>
<td>2.4</td>
<td>1.2</td>
<td>2.5</td>
<td>0.77</td>
</tr>
<tr>
<td>Jun-01</td>
<td>1.2</td>
<td>2.1</td>
<td>0.9</td>
<td>2.3</td>
<td>2</td>
</tr>
<tr>
<td>L wire</td>
<td>1.1</td>
<td>2.2</td>
<td>0.7</td>
<td>1.9</td>
<td>1.71</td>
</tr>
</tbody>
</table>

- IBS: $1 < r < 1.6$ (ATF)
  
  \[r = \frac{(\varepsilon_y - \varepsilon_{y0}) / \varepsilon_{y0}}{(\varepsilon_x - \varepsilon_{x0}) / \varepsilon_{x0}}\]
Constraints on measurement/optical errors from estimate of $r$

- for example – a coupled mixture, as would be generated by a skew quad

$$\varepsilon_{ymeas} = \varepsilon_{yreal} + k\varepsilon_x$$

(k independent of I)

- only makes sense if:

$$\frac{\varepsilon_y}{\varepsilon_{y0}} < \frac{\varepsilon_x}{\varepsilon_{x0}}$$

- inconsistent with 00/01 data
Orbit correction/emittance optimization

K. Kubo

Simulated vertical emittance after each correction

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>&lt;1.1E-11 rad-m</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>2.28</td>
<td>20 %</td>
</tr>
<tr>
<td></td>
<td>(E-11 rad-m)</td>
<td></td>
</tr>
<tr>
<td>V COD-dispersion</td>
<td>1.67</td>
<td>51 %</td>
</tr>
<tr>
<td>Coupling</td>
<td>0.58</td>
<td>91 %</td>
</tr>
</tbody>
</table>

Misalignment: as measured

+ random 30 micron offset

+ random 0.3 mrad. rotation

BPM error: offset 300 micron, rotation 0.02 rad.

Random seed ‘SAD’ simulation results
Ring orbits

- Raw BPM readings
- Energy spread measurement an excellent practical indicator of convergence

\[ \eta_{rms} \approx 3\text{mm} \]
Beam-based alignment

Each quad has an independent trim
- Refit model for each qtrim setting
  - for each of several local bump amplitudes, measure/fit qtrim kick:

<table>
<thead>
<tr>
<th>Name</th>
<th>Data Taken On</th>
<th>Y Offset w.r.t. nearest BPM (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QM17R.2</td>
<td>01APR18</td>
<td>-500.2 ± 24.9</td>
</tr>
<tr>
<td>QF2R.10</td>
<td>01APR26</td>
<td>+52.5 ± 11.9</td>
</tr>
<tr>
<td>QF2R.11</td>
<td>01MAY15</td>
<td>-161.6 ± 7.0</td>
</tr>
<tr>
<td>QF2R.12</td>
<td>01MAY15</td>
<td>-612.3 ± 25.9</td>
</tr>
<tr>
<td>QF2R.13</td>
<td>01MAY15</td>
<td>+160.9 ± 10.2</td>
</tr>
<tr>
<td>QM16R.2</td>
<td>01MAY15</td>
<td>-0.4 ± 4.2</td>
</tr>
</tbody>
</table>

Typical BBA resolution: 10µm
Quad/BPM Offset rms: 300µm

Repeatability – not tested
# BPMs ~100
Summary – single bunch low emittance

- relative growth *not* explained by aberrations in extraction line
- ring simulation indicates unreasonably small vertical emittance
- ring tuning relies on poorly optimized BPM system

- Plans: → reduce coupling and speed up optimization
  - complete ring beam-based alignment
    - How realistic is the simulation input?
      - In particular the rotation estimates of ~ 1 degree for BPMs
  - BPM system improvements
    - extraction line (RF dipole mode cavity BPMs)
    - ring
Single bunch study plans

- ZDR prediction for $\varepsilon_x$ @ 2 GeV: ~ 20% growth at 1e10
  - What is the impact of the ATF result on the NLC damping ring design?
- $\varepsilon_{yo}$ is too high
  - coupling and dispersion correction
  - BPM resolution and beam-based alignment
  - understanding of low intensity, low emittance instrument resolution
- Simulation done with equilibrium beam – not extracted beam (1.4 x)

$$r = \frac{(\varepsilon_y - \varepsilon_{yo}) / \varepsilon_{yo}}{(\varepsilon_x - \varepsilon_{xo}) / \varepsilon_{xo}}$$
Emittance measurement devices

- wire scanners - in the extraction line…
  - few micron beam size resolution
  - 2-3 micron beam jitter
  - control of η to few mm
- laserwire – in the ring…
- energy spread – extraction line optics
- SR monitor (results not included)
Extraction line cavity BPMs

- C-band
- Developed and built at Protvino
  - 6 ea installed 2001
  - 200 nm resolution
- show 4 µm rms beam centroid motion
  - $(\sigma/3)$
SR interference monitor (X)

Double Slit

f=600mm Lens

Polarization filter

SR interference monitor (Y)

CCD Camera

x5 magnifier Lens

Band Pass Filter 500nm

2nd Lens

Streak Camera

SR

Bending Magnet

Source Point

Source Point

Bending Radius 5.73m

Electron Beam

2nd SR port

Mirror

1st Mirror

Mirror

Mirror

5375

6045

2nd Mirror

Source Point

2nd SR port in Oct. 2000

SR monitor optics set-up

2nd SR port in Oct. 2000

ATF at KEK - Marc Ross/SLAC
Synchrotron radiation interferometer

- measure depth of 2 slit modulation vs slit spacing
- 6.2 um
- $\varepsilon_y \sim 1.6 \times 10^{-11}$
- beats diffraction limit by $\sim 6 \times$
- Problems:
  - centering
  - stability (esp. vibration
  - mirror damage
  - no light at large angles
    (also apertures)
**Principle of the laser wire**

- **Optical cavity**
- **Electron beam**
- **Laser wire**
- **CW laser**

**Count rate on Single bunch : N**

\[
N = \frac{W}{\sqrt{2\pi\hbar\nu c}} \frac{N_e}{\sigma_{meas}} \int_{\theta_c} d\sigma_{\text{compton}} d\Omega
\]

- \(N_e\) : Number of electron \((10^{10})\)
- \(\sigma_{meas}\) : Measured size \((10\mu m)\)
- \(W\) : Laser intensity \((10W)\)
- \(\hbar\nu\) : Laser wavelength \((532nm)\)

**Written by H.Sakai**

One scattered particle per 2000 turns
**Data taking procedure**

1. Set the table position

2. Strage electron beam in damping Ring.

3. Data taking every 1 second

4. Finish the data taking after 10-15 minute.

5. Change the table position

6. Continue from 2. to 5. until getting the beam profile

1 run corresponds to the procedure 2.-5.

**Electron current history on 1 run**

**Count rate on each comparator level on 1 run**

Comparator ~ compton energy discriminator

*Written by H.Sakai*
Ring Laserwire monitor

- Resonant cavity close to focus cut-off
  - uses CW laser
  - cavity gain 300
  - measurement ~ 1 hour

Signal Counting Rate (Hz/mA) vs Laser wire vertical position (um)

Horizontal range: 15 - 25 MeV

Vertical emittance (rad-m)

- 2000/12/05
- 2000/12/14
Development of a transition radiation profile monitor - OTR

- some controversy over minimum resolvable beam image
  - achieved 7µm (12/00) well beyond purported limit – *OTR provides light at very large angles → high resolution*
  - much better than synchrotron radiation
  - smallest OTR spot imaged to date
- theoretical limit: ~ λ

- Parameters for ATF OTR (built at SLAC)
  - resolution – 2µm
  - field of view – 300 x 200 µm (or ~2x)
  - depth of field – 8 µm vertical displacement
  - OK light for normal camera – 5e9 ppb
  - Industrial microscope objective
  - 35 mm working distance
  - various target materials
successive images illustrating damage:

- Cu
  - $7 \times 10^9$
  - 20x12µm

- Be
  - $5 \times 10^{10}$
  - 10x13µm

OTR images & target damage
IBS is incoherent, beam size growth slope **should** be the same at all scanners.

<table>
<thead>
<tr>
<th>Monitor</th>
<th>Slope – σ_y / I (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS – MW4X</td>
<td>3.94 μm/ 1e10</td>
</tr>
<tr>
<td>WS - MW3X</td>
<td>1.84</td>
</tr>
<tr>
<td>OTR Imager</td>
<td>3.99</td>
</tr>
</tbody>
</table>

Be OTR and wire scanner *vs* I

\[
y = 15.4 + 3.94 \times 10^{-10} x \\
\rho = 0.905 \\
\chi^2/N = 0.216
\]

\[
y = 11.0 + 3.99 \times 10^{-10} x \\
\rho = 0.942 \\
\chi^2/N = 0.132
\]

\[
y = 7.2 + 1.84 \times 10^{-10} x \\
\rho = 0.905 \\
\chi^2/N = 0.216
\]
Quad-emittance scan – OTR and nearby wire scanner

<table>
<thead>
<tr>
<th>Device</th>
<th>$\varepsilon_y$</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTR</td>
<td>27 ± 1 pm</td>
<td>quad scan</td>
</tr>
<tr>
<td>OTR no tilt</td>
<td>18 ± 1 pm</td>
<td>Tilt removed from Y scans</td>
</tr>
<tr>
<td>MW3X</td>
<td>22 ± 1 pm</td>
<td>quad scan</td>
</tr>
<tr>
<td>MW4X</td>
<td>28 ± 1 pm</td>
<td>quad scan</td>
</tr>
<tr>
<td>5 wire</td>
<td>26 ± 1 pm</td>
<td>multi-wire scan</td>
</tr>
</tbody>
</table>

Wire scanner

MW4X $\varepsilon_y^2$ vs QD8X

- $p_0 = 597.1 + 14.79$
- $p_1 = 2286 + 106.6$
- $p_2 = 4760 + 157.2$
- $A = 4760.25$
- $B = -0.24009$
- $C = 322.75$
- $\text{RMS} = 64.9 \mu$m
- $\chi^2 / N = 2.474$

5 wire

- $\varepsilon_y^2$ multi-wire scan
- $\text{RMS} = 64.9 \mu$m
- $\chi^2 / N = 2.474$

OTR screen

OTR $\varepsilon_y^2$ vs QD8X K1

- $p_0 = 272.2 + 14.79$
- $p_1 = 909.5 + 106.6$
- $p_2 = 1781 + 157.2$
- $A = 1781.2002$
- $B = -0.25531$
- $C = 156.1047$
- $\text{RMS} = 26 \mu$m
- $\chi^2 / N = 2.779$
Beam Dynamics from Loss monitors - BESSY

BESSY data

I & bm-gas & Touschek Losses vs tune

P. Kuske

PMT output and discriminated counts

Touschek losses vs time – 1 store cycle

ATF data

8/30/01

ATF at KEK - Marc Ross/SLAC
ATF loss monitor counter installation

BESSY loss monitors mounted in pairs to count Touschek coincidences
Multi-bunch operation

Multi-bunch intensity vs time

ATF multi-bunch parameters:

• up to 4 each 20-bunch trains
• bunch spacing 2.8 ns
• typical I/bunch ~ ¼ of single bunch ops

• Focus so far:
  • Instrumentation
  • Throughput
  • Source / linac loading compensation
    • Gun pulser distortion
    • SHB loading
Multi-bunch operation-extraction line wire scans

Cerenkov light from avalanche photodiode – all bunches scanned at once

Distortion caused by?

6/21/2001 multibunch wire scan
Multi-bunch operation
extraction line wire scans

- 20 bunches; typical single bunch Imax ~ 2.5e9 (4x lower than single bunch)
- $\varepsilon_y$ increases 1.5x
- vacuum system improved 2001
ATF Operation

- ATF operates 20 weeks/year for a 4 1/3 day block /week
  - ~ 2 wks on/ 2 wks off (startup effects are significant)
- Users (~ students) get about 1/4 time
  - Effective uptime ~ 55 days/year
- Stability is critical for ~10 pm emittance
  - Typical beam sizes are 50 x 8 µm
- Single shot BPM resolution is ~15µm
- Beam pulse rate is 1.5 Hz

- Precise measurements require long periods of checking/setup
ATF Support

- Operation is limited by funds (KEK) and manpower (KEK)
  - ~10 physicists (6 FTE) + 8 graduate students
  - SLAC participation began 1997
    - 1 FTE average by ~ 8 SLAC staff travelling to ATF
    - ~ 100K$ / year for hardware development
  - Contributions from Japanese universities and BINP/Protvino
  - Minimal involvement from other labs (CERN, DESY…)

8/30/01
ATF Plans

- ATF is the only LC test facility with capability for transverse beam dynamics studies
  - collective effects, tolerances, optimization, control, stability, technology…
  - dynamics of small beams is critical for all proposed LCs

- ATF will be used for pioneering physics research and engineering development studies
  - We must examine ways to extend ATF for the study of LC emittance propagation
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( ___ → helped with presentation)

8/30/01