IP nano-BPM for ATF IP, laserwire, (and IP beam size monitor)

- nano-BPM system for ATF and ATF2
- Optical cavity laserwire as a miniature model of photon facility.

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ATF2 ws(SLAC)
Nano-BPM and related works

- nano-BPM study at ATF
- Laser interferometer and straightness monitor
- Possible improvement for IP nano-BPM (V. Vogel)
nano-BPM study at ATF (KEK team)

• Phase-1 (~Oct. 2005):
  • Goal is to prove < 2nm resolution.
  • Includes the development of Q-BPM (required resolution: 100 nm)
  • Setup
    • 3 new BPMs are placed on individual alignment movers.
    • Active movers stabilize the BPM position.
• Phase-2 (simultaneous with ATF2 commissioning):
  • SLAC/LLNL team is developing similar system.
  • Long term stabilization of the two systems (~10m distance).
  • Stability test of the girder.
  • Energy spectrometer development.
  • Beam feedback to sub-micron.
Mover system

- Monolithic elastic hinge with piezo actuators
- Well separated 4-direction mover (X,Y,Yaw,Pitch)
- high stiffness (>100Hz)
- active movers on the top
Active stabilization

- Laser interferometer monitors the BPM position with respect to reference bar.
  - Michelson-type interferometer is attached on the reference bar.
  - One of the arms is formed by a mirror glued on the top of the BPM.
  - Fringe signal is read out by a PD.
  - The resolution is limited by the environmental stability, ~1 nm.
- Active PZT mover locks the fringe pattern.
  - Feedback works up to 100 Hz, which is determined by the mass and the stiffness.
Laser straightness monitor

- This will be useful in phase 2.
- Long scale (~5 meter) straightness monitor to monitor:
  - floor
  - reference bar
- Laser beam gives a straight line:
  - laser path will be in a vacuum condition.
- High resolution position monitor even with a big spot size (1 mm):
  - A pair of photo-diode forms a balance-receiver.
  - Preliminary result: 10 nm, 5 urad resolution
Cavity BPM

- Three brand-new cavities
  - originally developed for Q-BPM.
  - reference and sensor in one block
- conventional electronics (analog mix.)
  - easy to readout
- Beam test just started.
  - electronics noise ~50nm.
  - preliminary test result 300nm res.
- Scenario to 2nm
  - Understand the cavity signal (calibration, mode-coupling, etc...)
- Low-noise electronics, low-loss signal transfer.
- Vibration stabilization with the active mover.
Possible improvement for IP BPM (V. Vogel)

- Long bunch length at ATF (8 mm).
  - existing BPMs are optimized for 8mm bunch length.
- With bunch compression, stronger signal is expected with higher frequency cavity.
- Common mode leakage
  - The electrical center can be shifted by the interference with common modes.
  - Electric center may be influenced by the bunch length jitter (~5 nm for 5% sigma_z jitter).
• To be free from the coupling problem,
  • Separate cavity for X and Y positions.
  • Split the frequencies of two dipole modes.
• Not to be influenced by common modes,
  • Damped-Q for symmetric modes.
  • magic-T inside the block.
• To improve signal intensity
  • smaller beam pipe diameter (~7mm).
  • higher freq. if bunch compression is possible.
• for beam divergence at IP
  • smaller gap not to be influenced by the beam angle.
  • angle measurement by the reference cavity.

BPMs for FF
composite of three cavity.

1. Reference phase, bunch length measurement, bunch angle/tilt.
2. For X position measurement.
3. For Y position measurement
4. Loss part for damping high order modes
Pulse-Stacked Laserwire

- Experience of laser-beam collision
  - High-gain optical cavity
  - Mode-lock pulsed laser
- Motivation is to develop Compton X-ray source
- Possibility to improve the signal rate of existing DR laserwire
- A miniature model of photon facility
Principle

- Laser pulses are resonantly enhanced inside of an optical cavity. High intensity laser target can be realized.
- Resonance conditions
  - Phase (standing wave): cavity length
  - Repetition (envelope)
- Cavity round-trip time have to coincide with
  - Beam repetition
Performance

- Mirror
  - reflectance 99.7%
  - curvature 250mm
- Cavity
  - length 21cm (714MHz)
- Laser oscillator
  - wavelength 1064nm
  - 357MHz, 400mW
  - pulse length 7ps (FWHM)
  - passive mode-lock
- Enhancement
  - ~1000 with 714MHz laser.
  - ~500 with 357MHz laser.
Timing system

- Laser timing (repetition) is locked to ATF beam.
- LW cavity is controlled to keep the resonance, then the laser pulse inside the cavity is automatically synchronized to the beam.
Experimental layout

- Optical cavity is placed inside the vacuum chamber.
- Entire optical system (and the chamber) is mounted on a movable table.
Preliminary result

- **Position scan**
  - unlocked to the beam (random timing), and locked
  - beam size of laser is 120 um, which dominates the measured profile.

- **Timing (phase) scan**
  - pulse length of laser is 7 ps. It might be useful to measure bunch length.
Possible improvement for higher flux

- Laser
  - External amplifier for higher power
  - Repetition rate optimization
- Cavity
  - High reflectivitance mirror
  - Focusing optics (complicated cavity, ex. 4 mirror bow-tie or parabolic mirror)
- What limits the power enhancement?
  - Stability inside the laser oscillator (mechanical resonance)
  - Pulse-to-pulse phase slip
  - Peak-power?