Pulse stacking cavity at KEK-ATF

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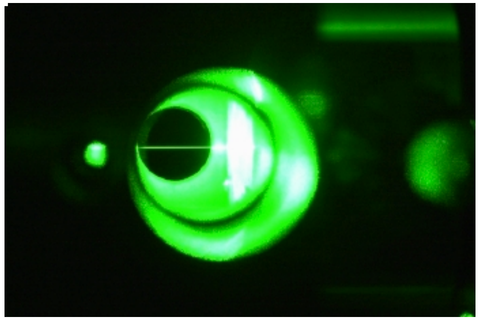
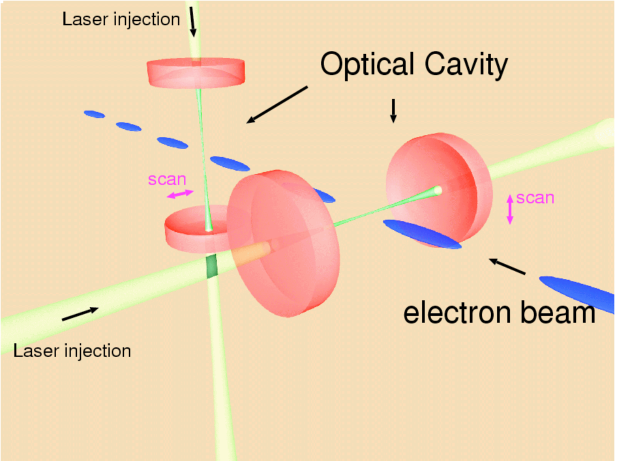
LCWS

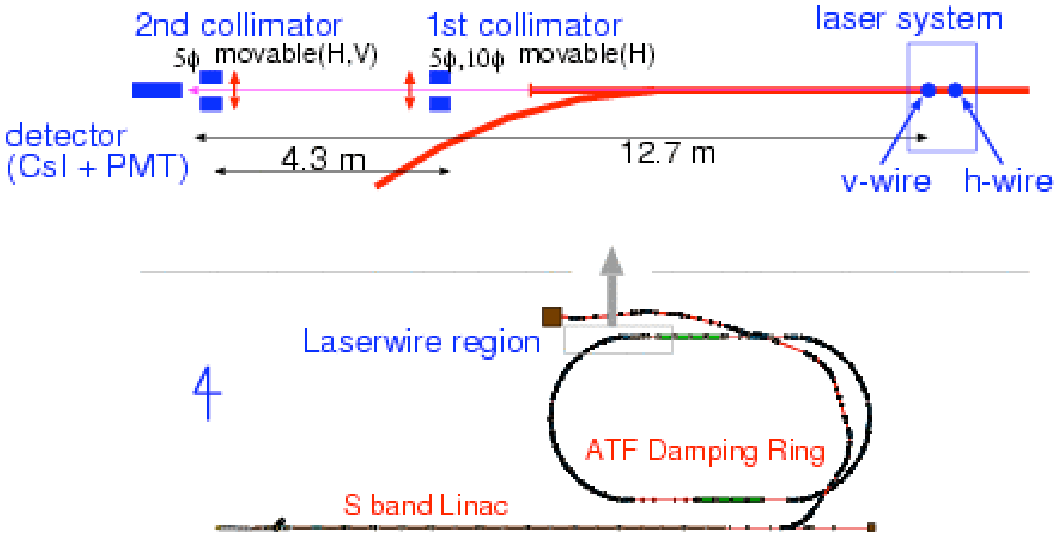
- Laser wire beam size monitor
- Basics of an optical cavity
- Development of a pulse optical cavity
- Beam collision experiment with laser pulse in an optical cavity

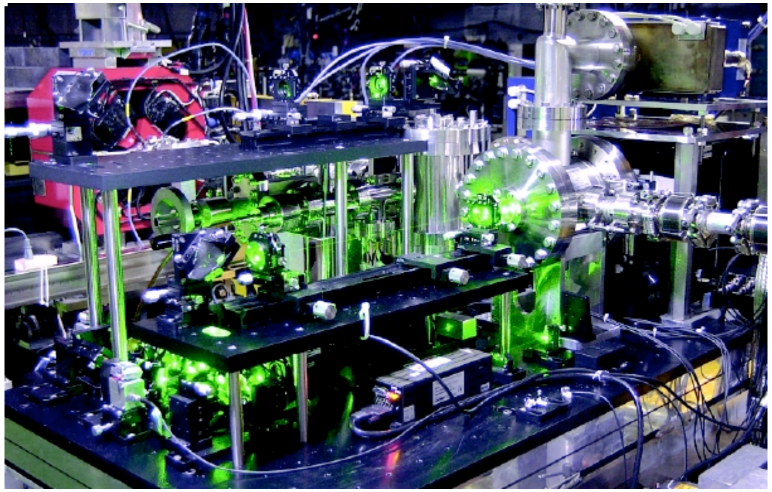
Laser wire beam size monitor

- Beam profile measurement in the ATF damping ring.
  - Scan the beam with a thin laser target.
  - Measure the flux of the Compton scattering signal as a function of the laser position.
- Feature
  - Non-invasive measurement.
  - Separately measure each bunch in multi-bunch.
- Optical cavity
  - enhance the effective laser power
  - determine the properties of the laser



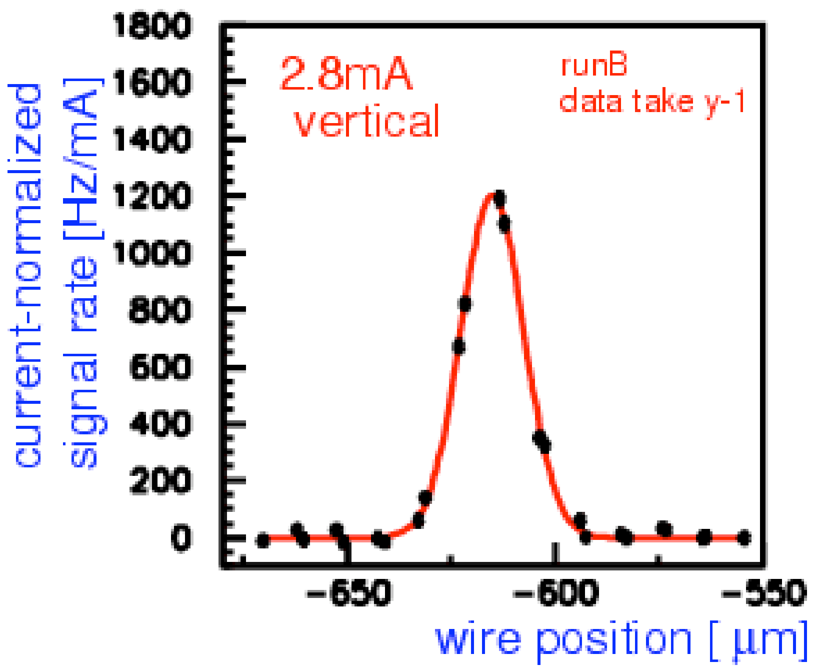


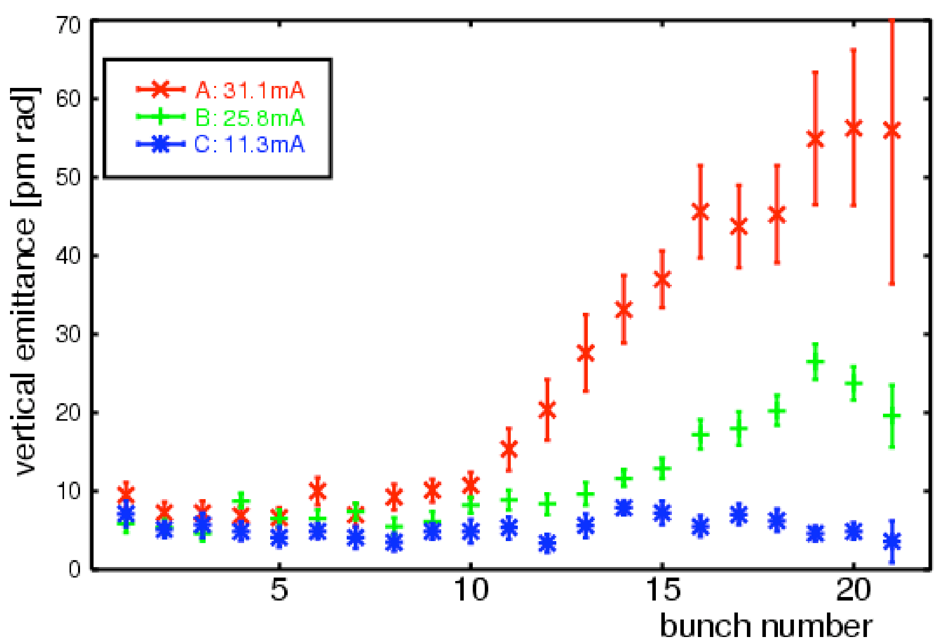




Example of the measurement

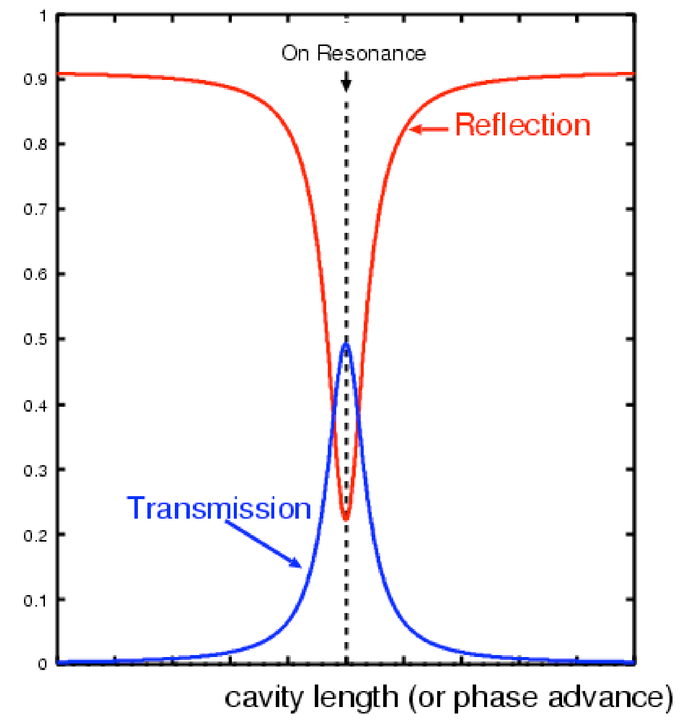
- Laser wire
  - laser: CW, 300mW, 532nm
  - cavity: 5.6micron (rms size), enhancement 660
- Electron beam
  - 5 micron (vertical size)
  - 2.8 nsec bunch spacing (multi-bunch)

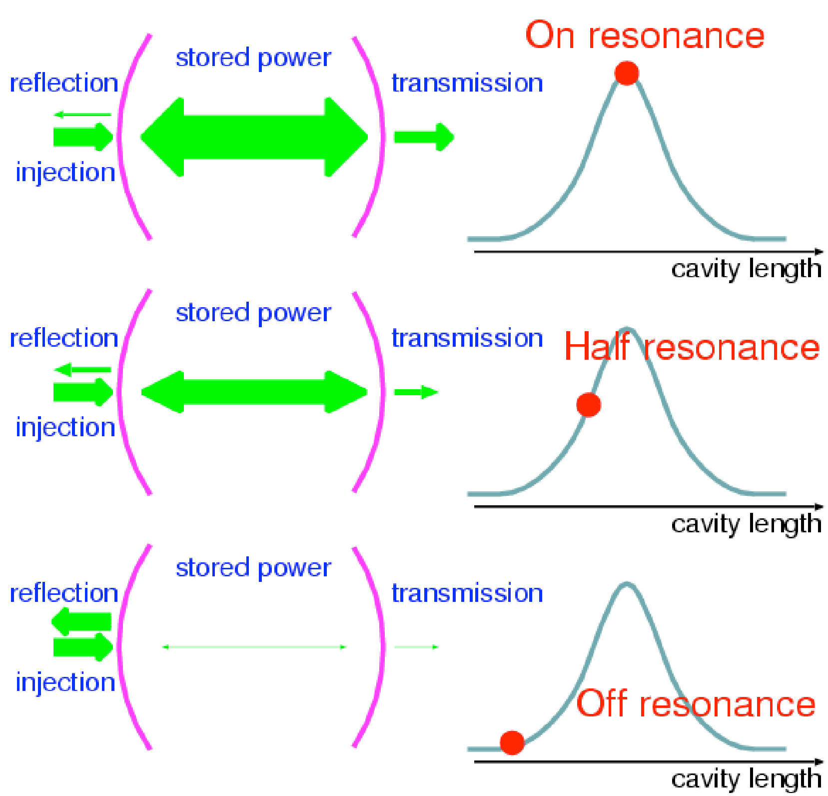


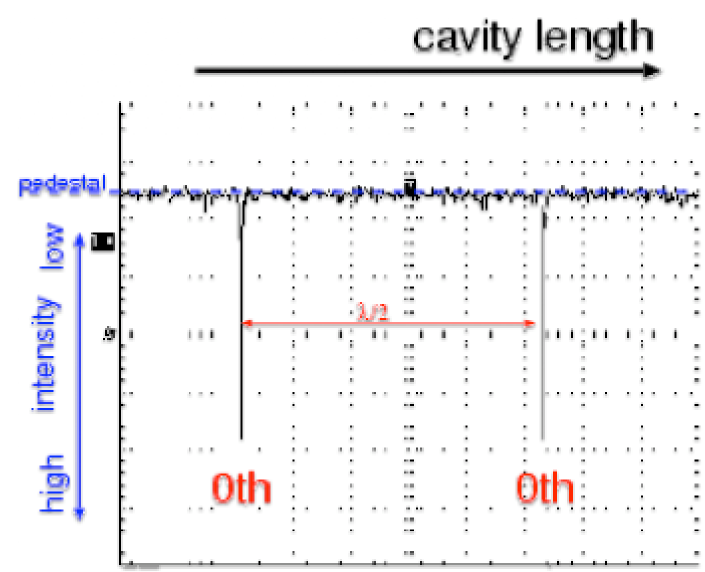


Control of an optical cavity

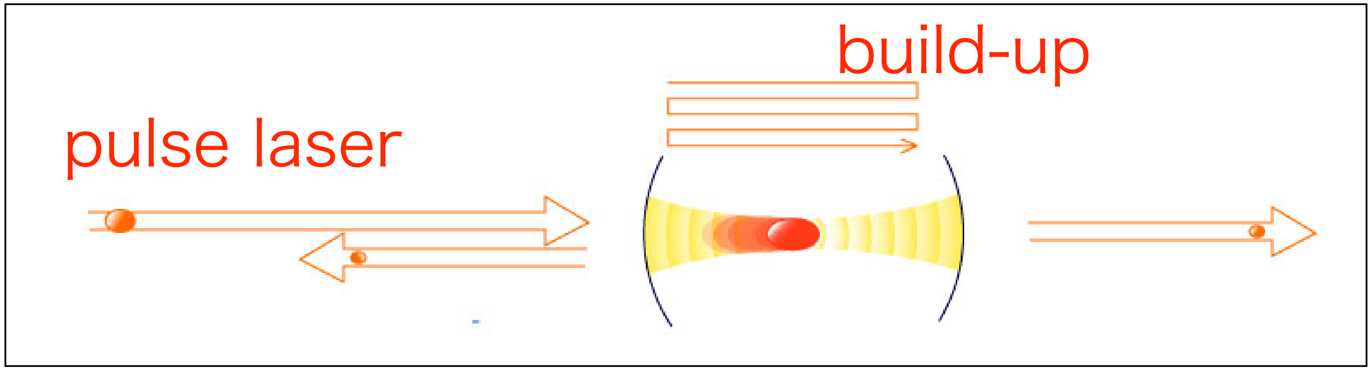
- Cavity resonance
  - Mirror distance = integer of half wave length
  - High reflectance mirror
    - high power enhancement
    - narrow resonance width
    - difficult to keep the resonance condition



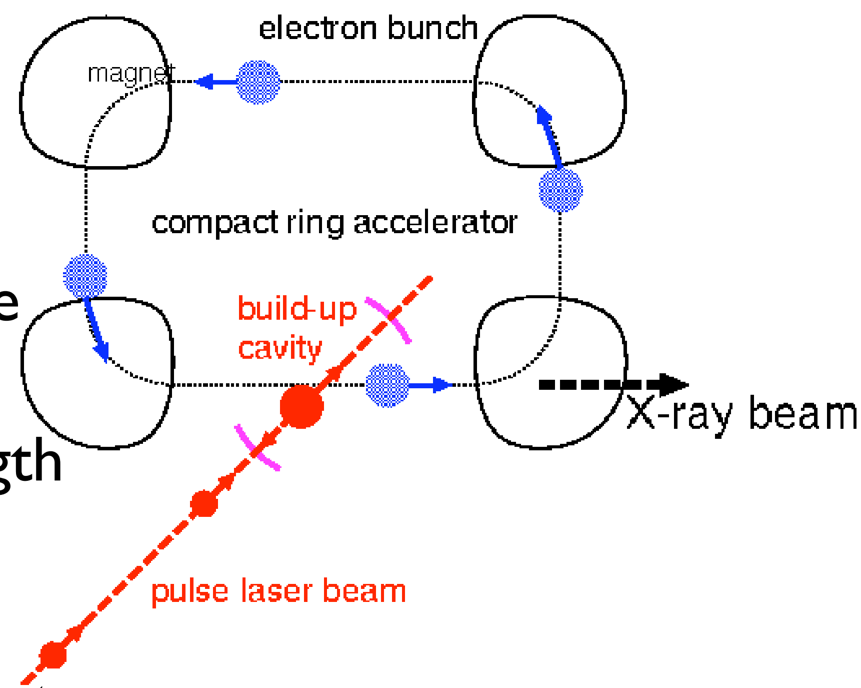




Development of a system with a pulse laser

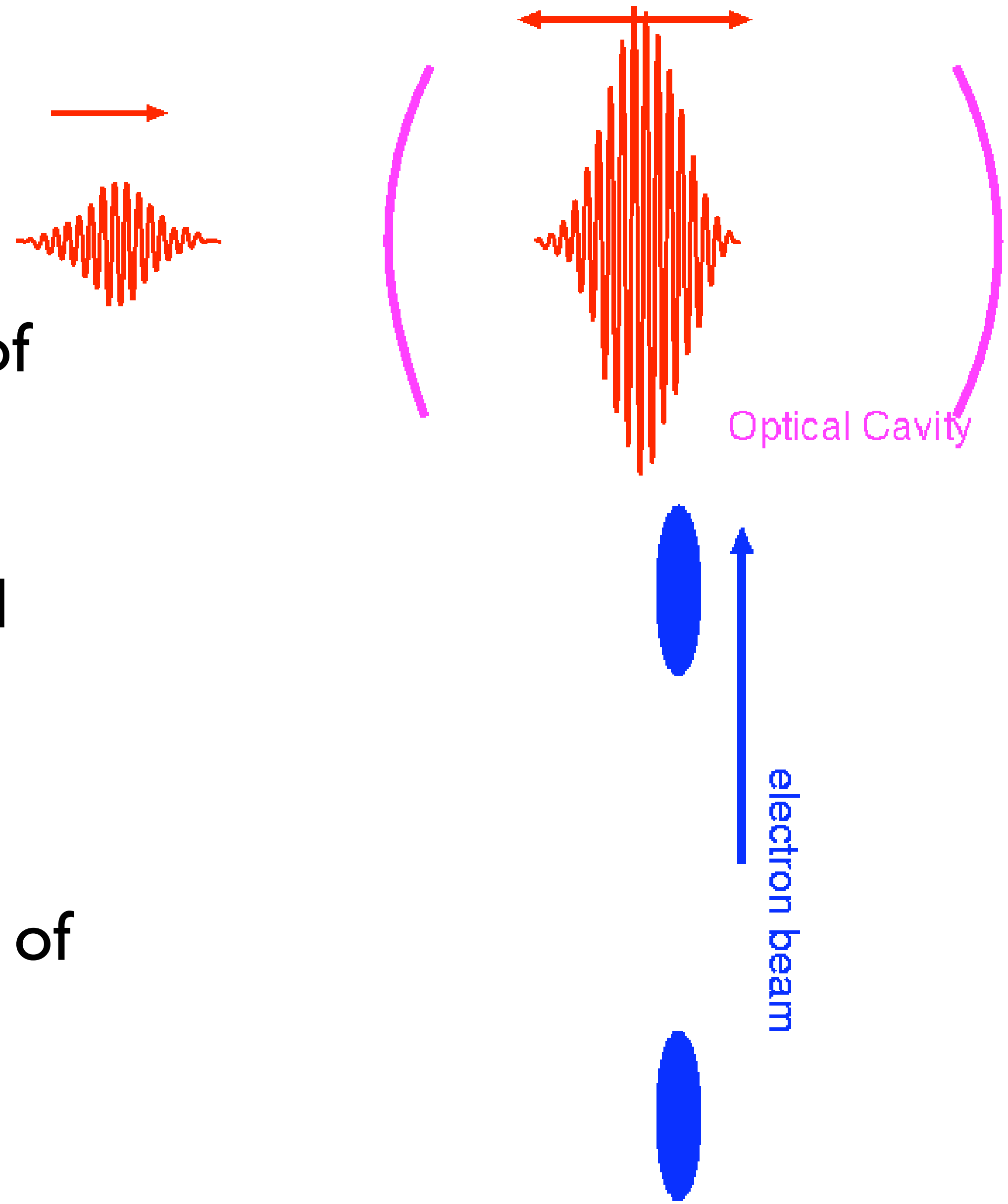


- Change the CW laser to a pulsed laser
  - much higher peak intensity
  - high intensity signal
- Compact Compton X-ray source
  - quasi-monochromatic X-ray
  - pulse X-ray synchronized to a laser pulse
- Issues
  - bunch spacing determines the cavity length
  - it also determines the laser repetition
- Test experiment at ATF
  - proof-of-principle with a pulsed cavity system.
  - realize a collision and detect the Compton signal.



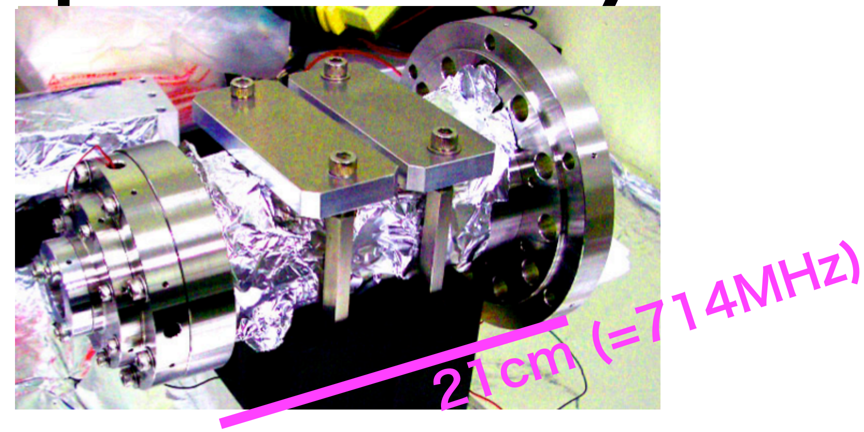
Optical cavity for a pulsed laser

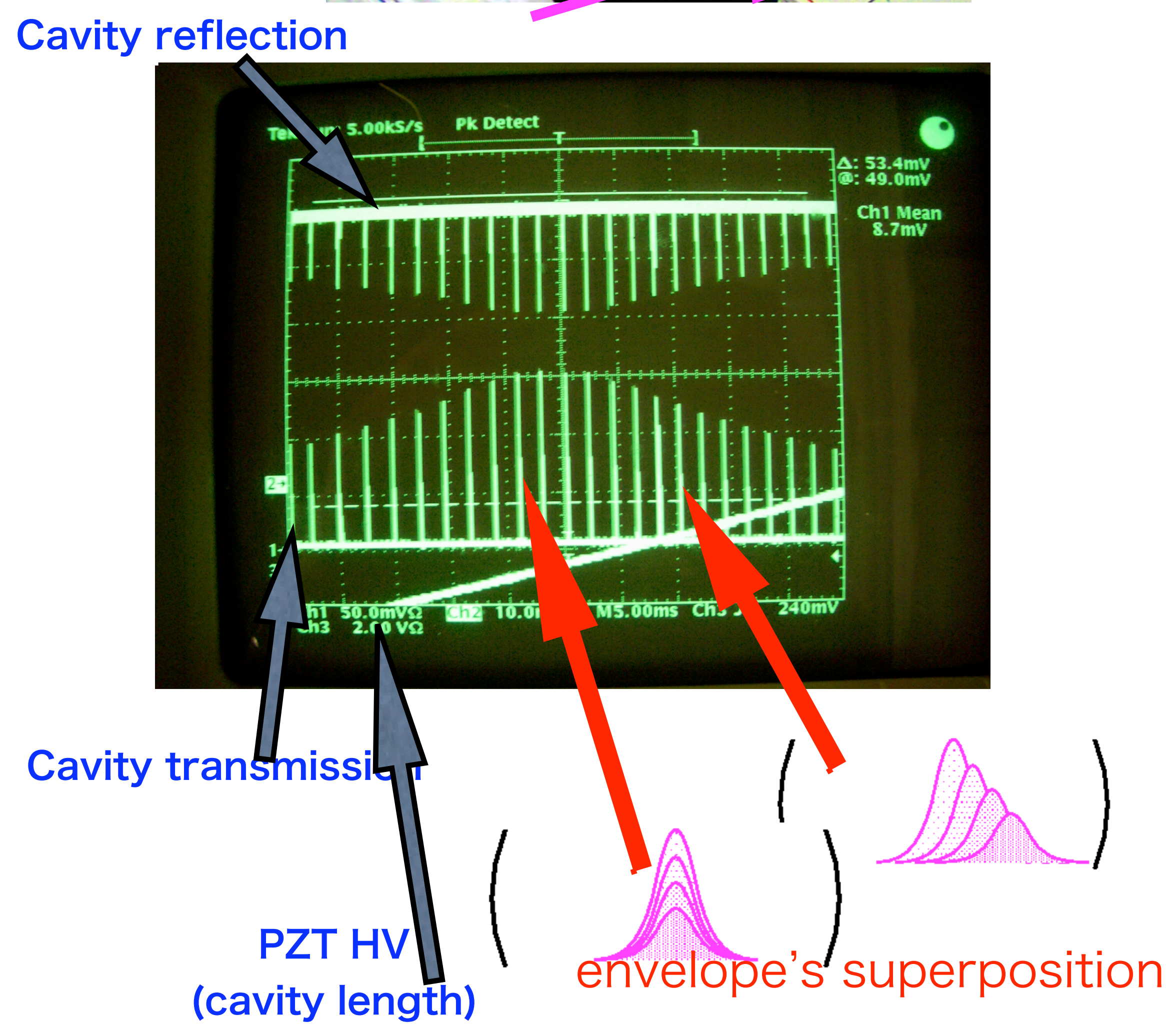
- Resonance condition
  - phase relation
    - cavity length = integer of half wave length
  - envelope superposition
    - laser repetition = round trip time of the optical cavity.
    - it needs to be coincide with the repetition rate of the electron beam.



Development of an optical cavity

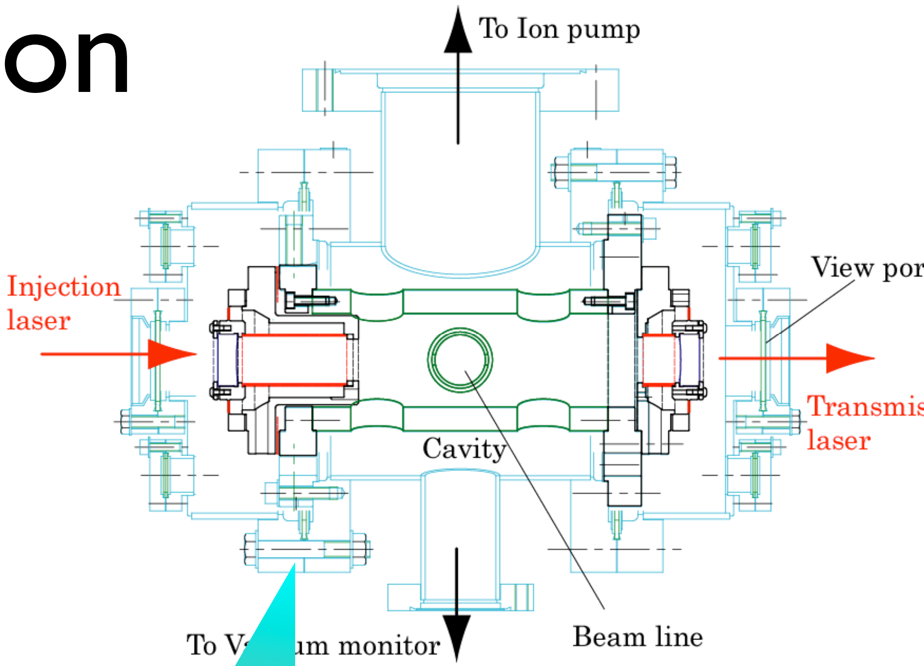
- Bunch repetition of ATF beam is 357 MHz
- Laser oscillator
  - wavelength 1064nm
  - 357MHz,400mW
  - pulse length 7ps(FWHM)
  - passive mode-lock
- Cavity
  - length 21cm (714MHz)
- Mirror
  - reflectance 99.7%
  - curvature 250 mm
- Enhancement
  - ~1000 with 714MHz laser.
  - ~500 with 357MHz laser.

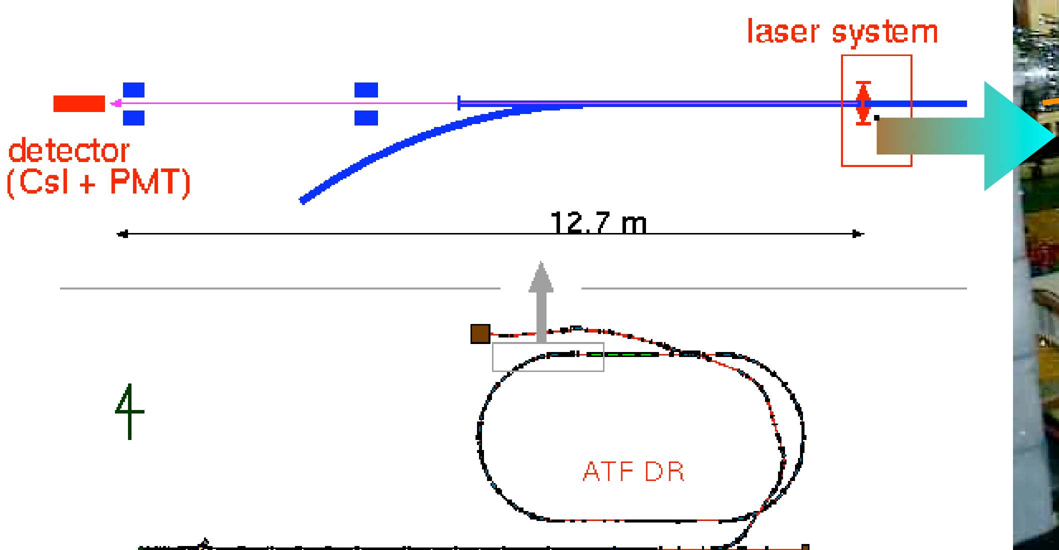


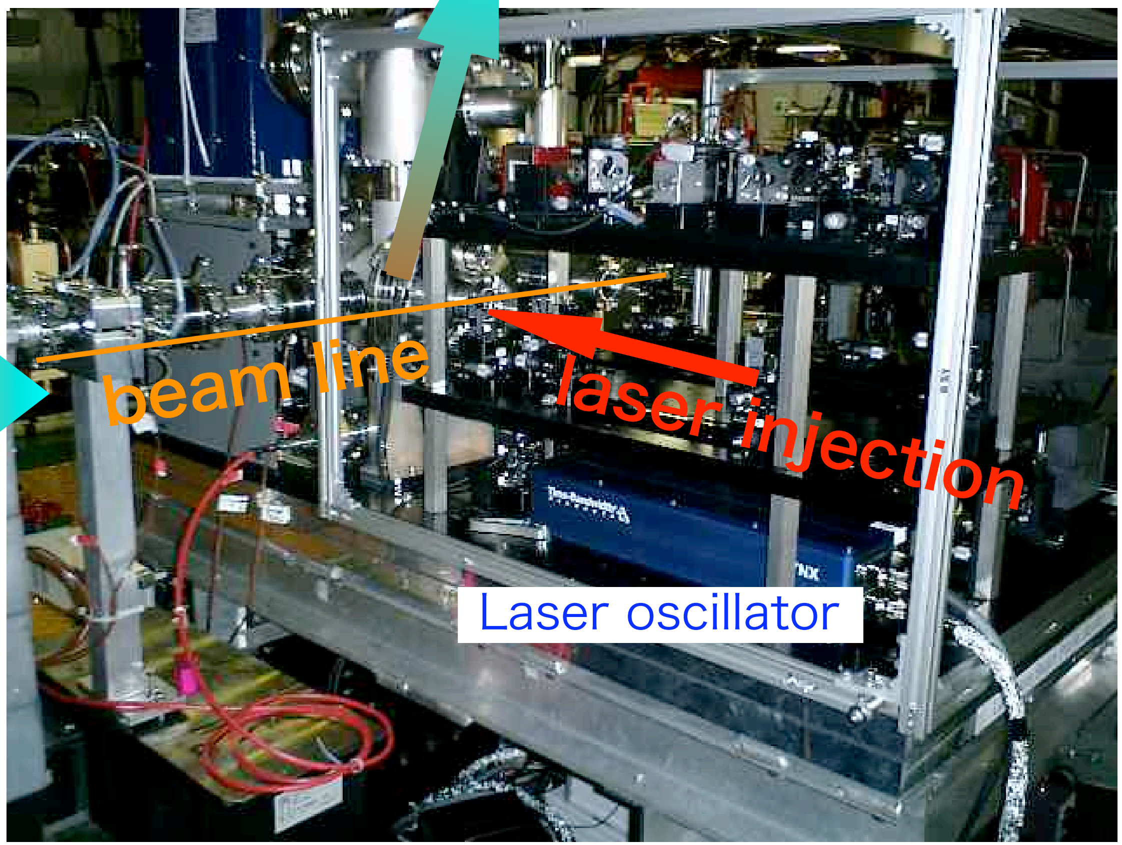


Installation

- Installed in Oct.2004.
- One of the laser wire monitor (for horizontal size measurement) was replaced to this system.
    - use same detector
- Entire optical system (and the chamber) is mounted on a movable table.

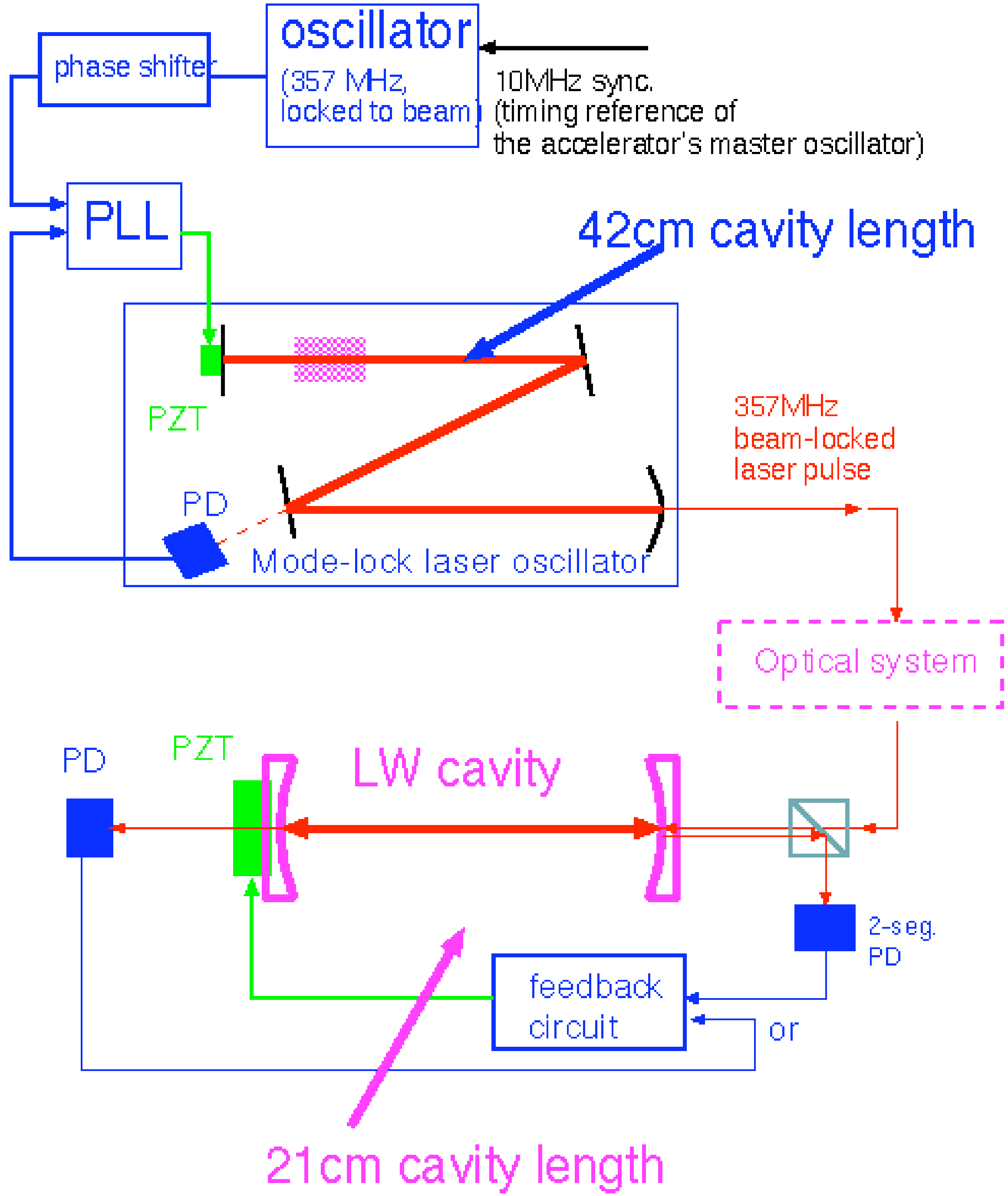






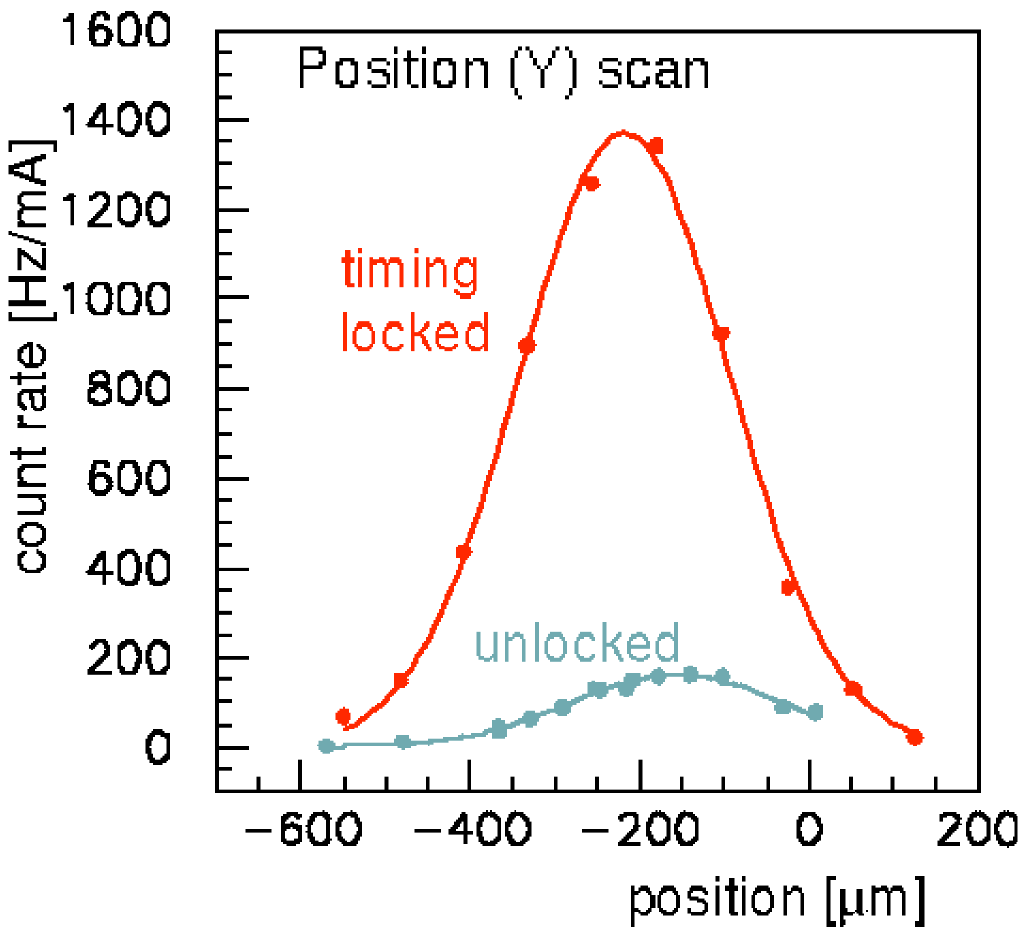
Timing system

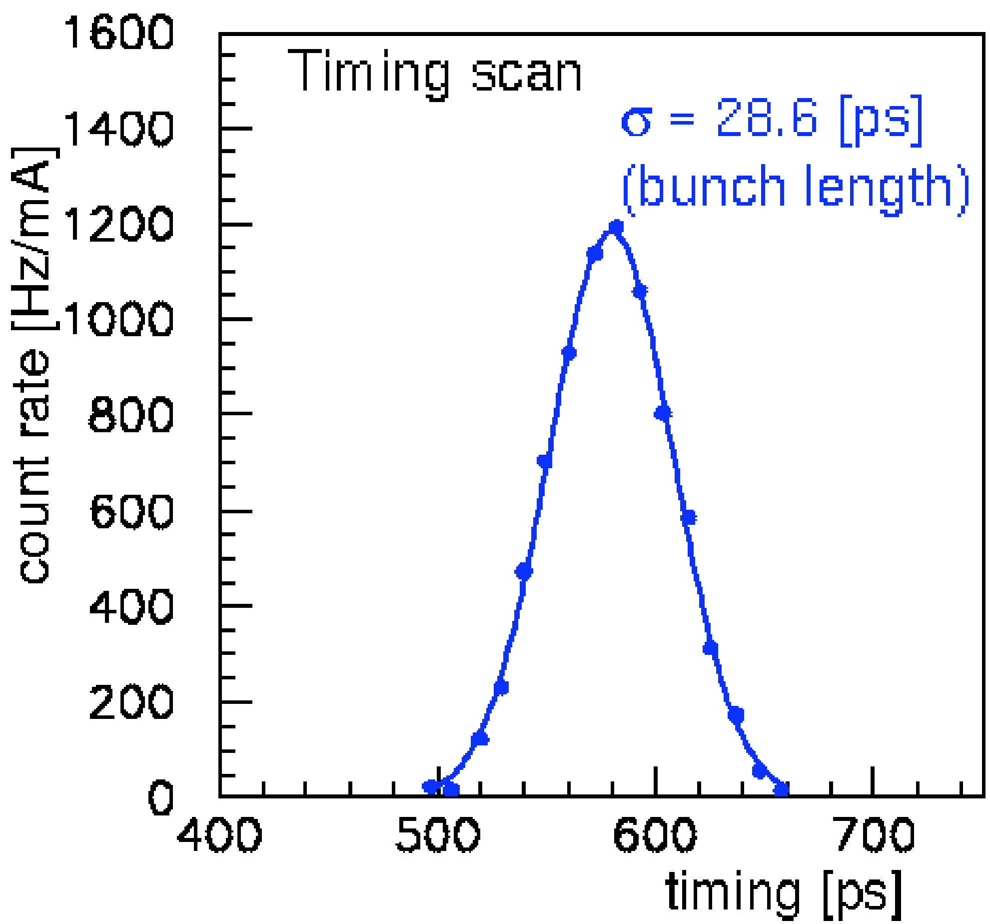
- Laser timing (repetition) is locked to ATF beam.
- LW cavity is controlled to keep the resonance, then the laser pulse inside the cavity is automatically synchronized to the beam.



Preliminary result

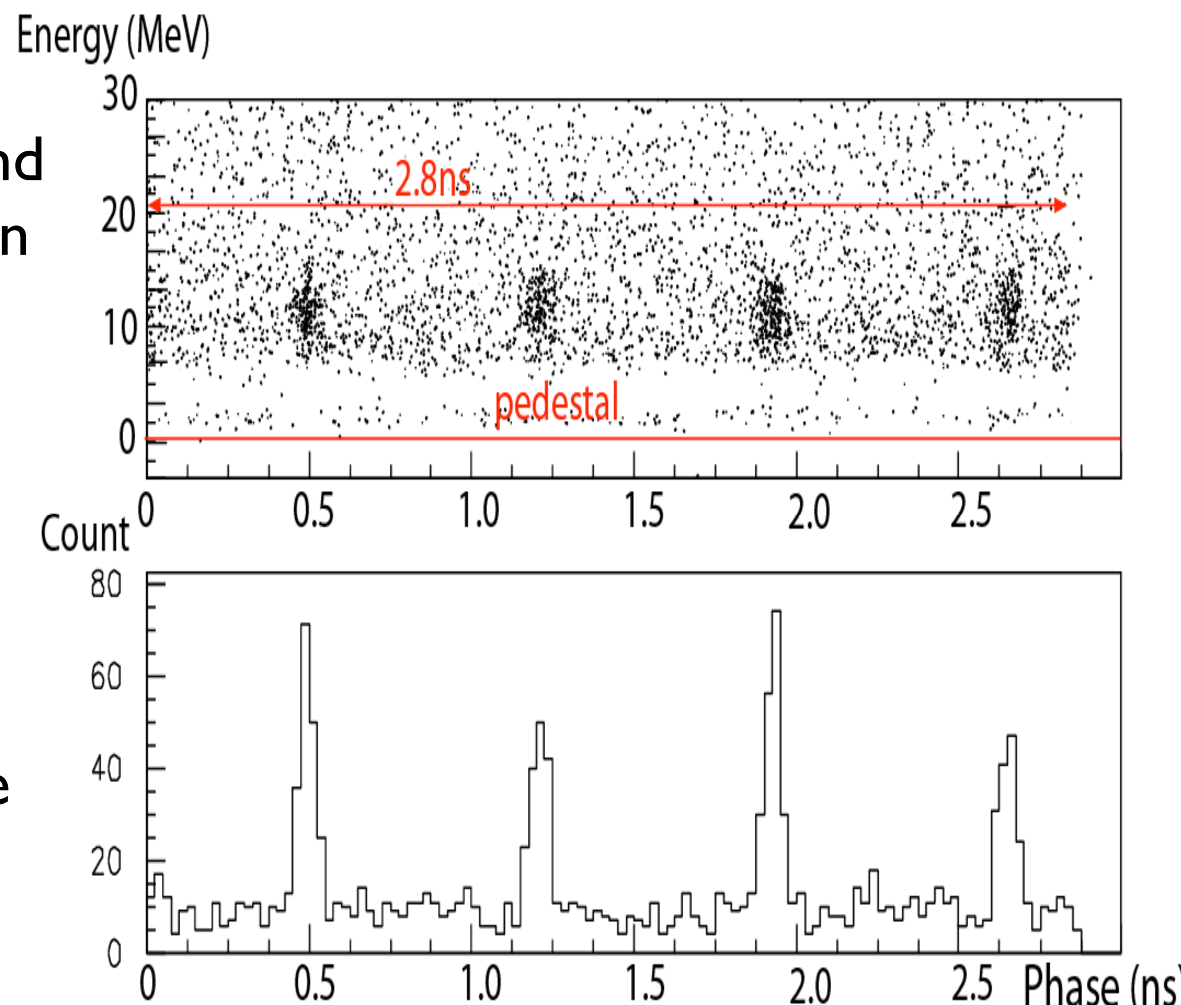
- Position scan
  - unlocked to the beam (random timing), and locked
  - beam size of laser is 120 um, which dominates the measured profile.
- Timing (phase) scan
  - pulse length of laser is 7 ps. It can be a bunch length monitor.





Preliminary result

- Longitudinal bunch structure measurement.
- Unlock the laser repetition, and add a small frequency offset on the laser rep-rate.
  - collision on random timing
- signal detection
  - relative phase of laser and electron
  - energy
- Four chances to collide in one cycle of the repetition.
  - two-fold optics
  - two chances in a round trip



Summary

- We have developed a laser wire beam size monitor based on an optical cavity technique.
- Replacing the cw laser to a pulsed laser enables us to expect a higher intensity Compton signal.
- We did a proof-of-principle experiment of such a pulsed cavity system at the ATF damping ring.