Monitoring Alignment & Stabilisation with high Accuracy

MONALISA

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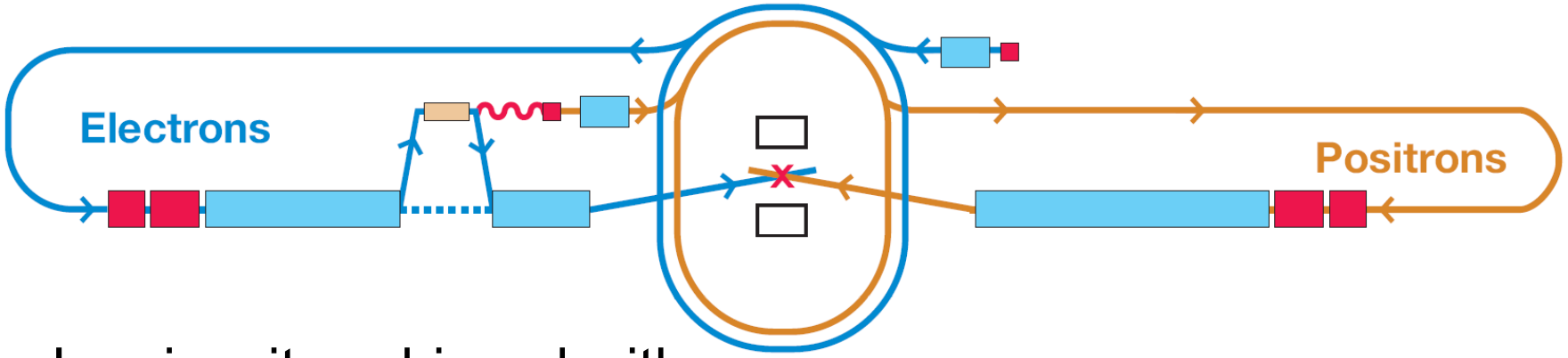
MONALISA

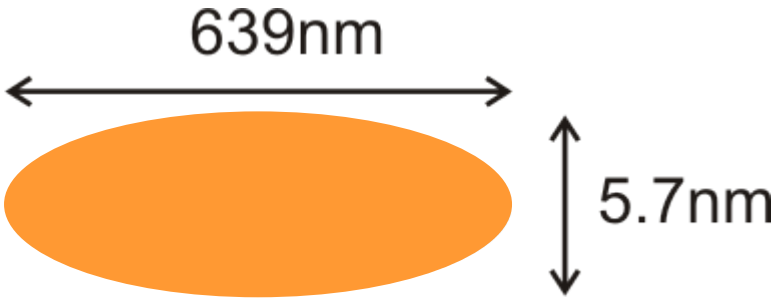
- Is an interferometric metrology system for continuous monitoring of position critical accelerator components
- To be used to monitor ILC final focus quadrupoles
- Consists of a fixed network of evacuated interferometric distance meters

Concepts

The ILC



- Luminosity achieved with small transverse bunch sizes at interaction point



- Bunches kept in collision with beam-based feedback system: FONT

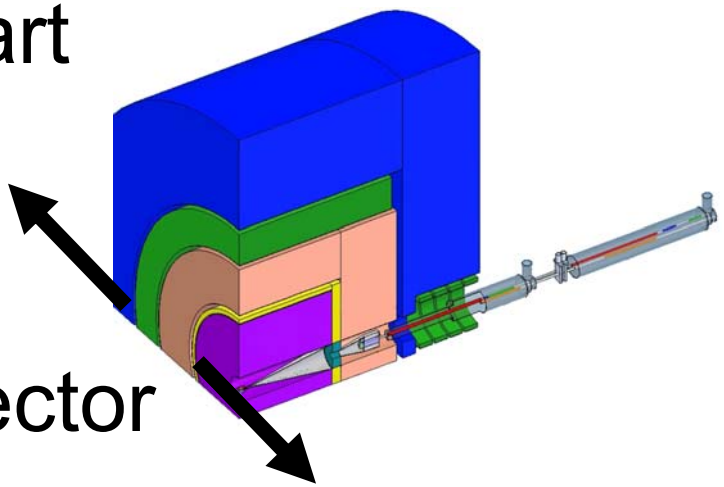
Bunch trains

- Bunches arrive at IP in “bunch trains”

- Beam based measurement systems “blind” between bunch trains
- But interferometers are not!

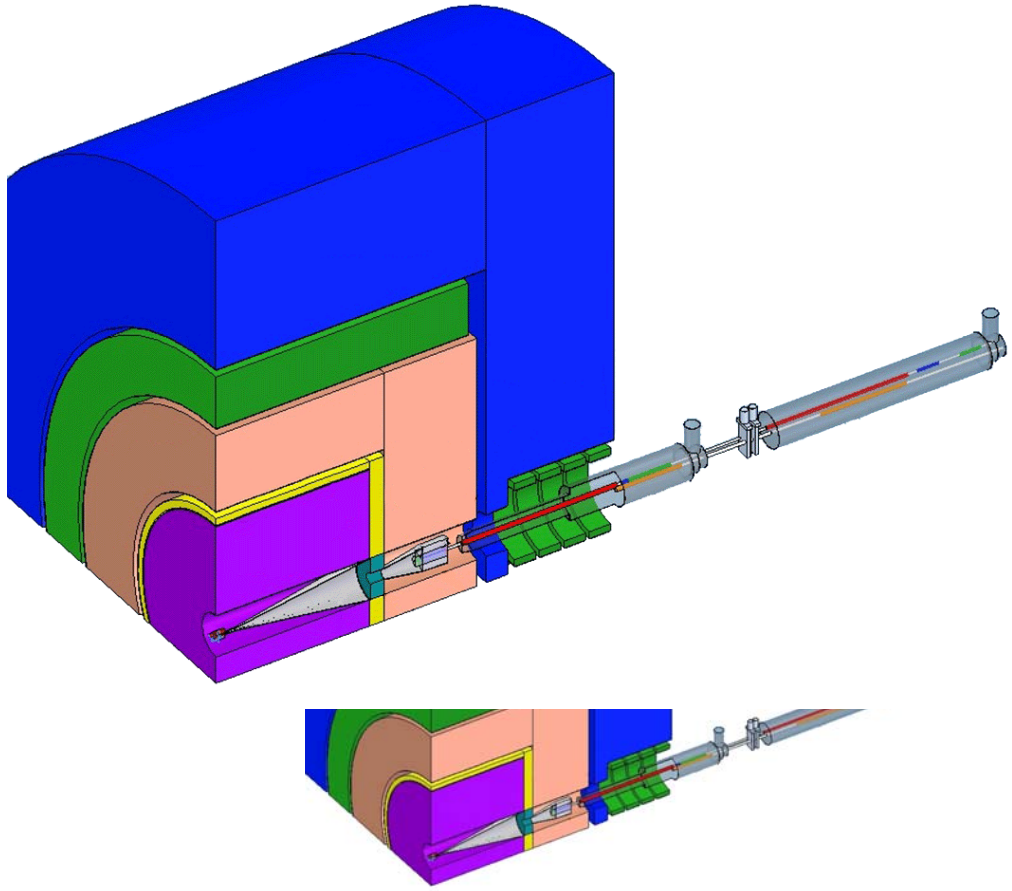
Offline periods, Push/Pull

- Measure drifts during offline periods
- Aid faster machine restart



- QD0s buried inside detector
- Detectors periodically moved: “push/pull”
- This will cause misalignments

Geometry

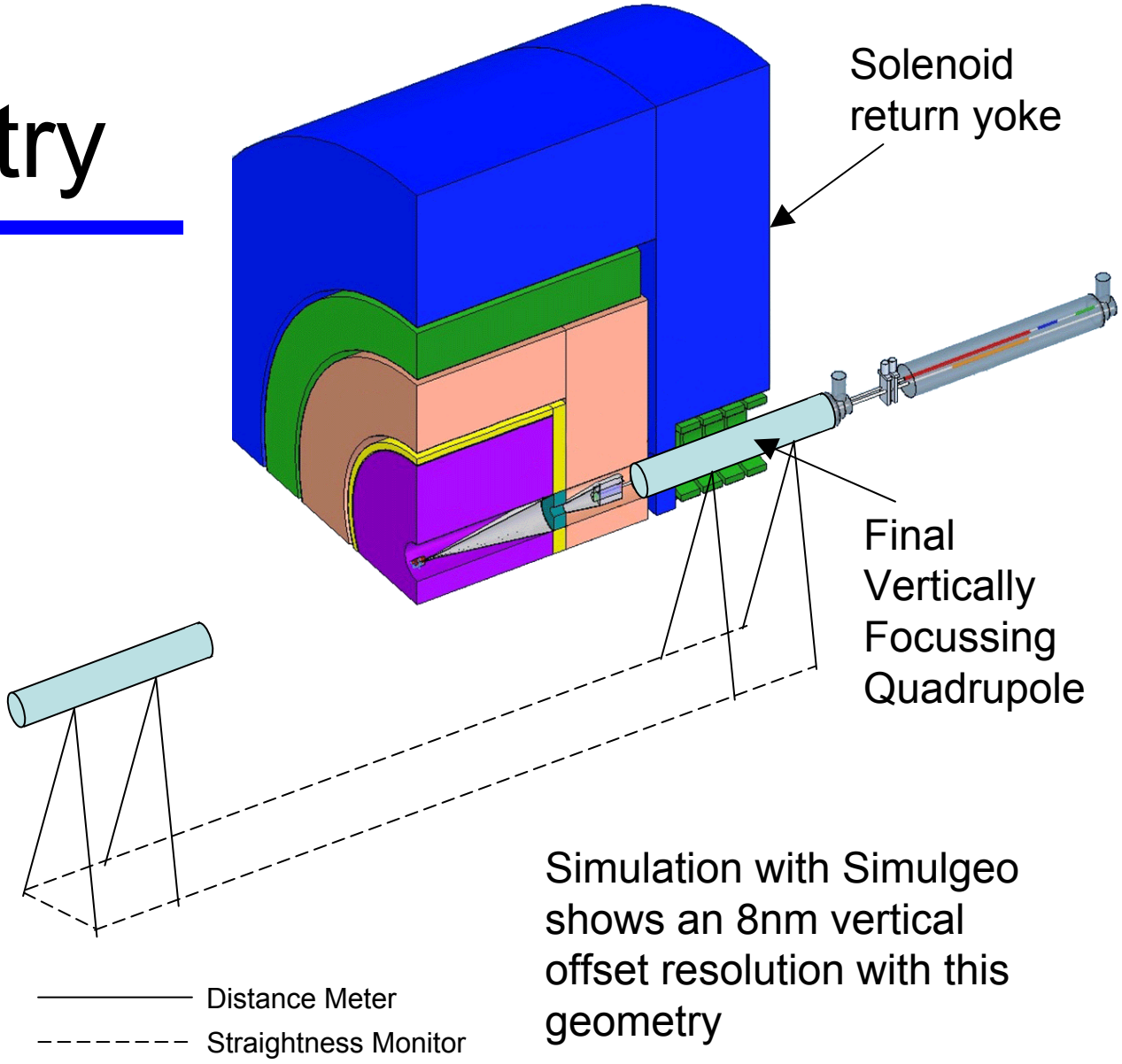


Geometry

Measure movement of QD0s with respect to some points radially outwards through detector field yoke

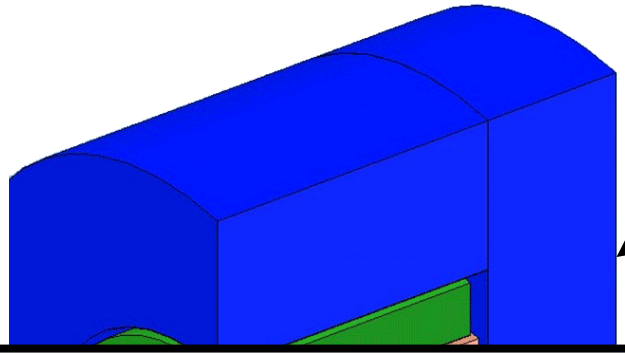
Then must measure the relative motion of these end points

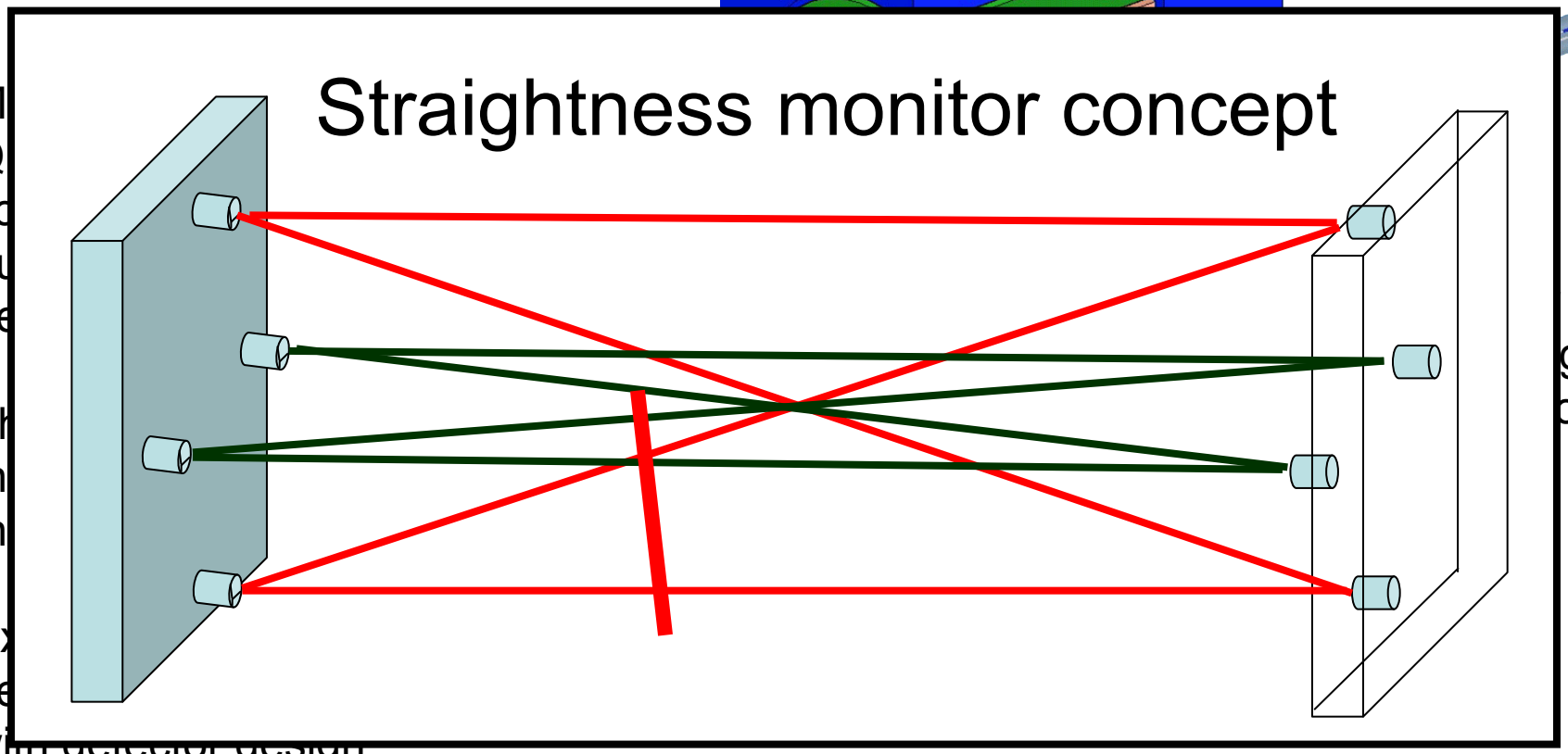
Exact geometry to be determined in synch with detector design



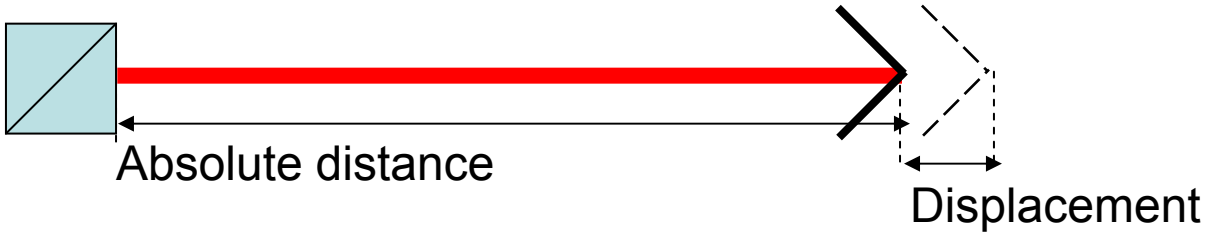
Simulation with Simulgeo shows an 8nm vertical offset resolution with this geometry

Geometry





Measurement lines

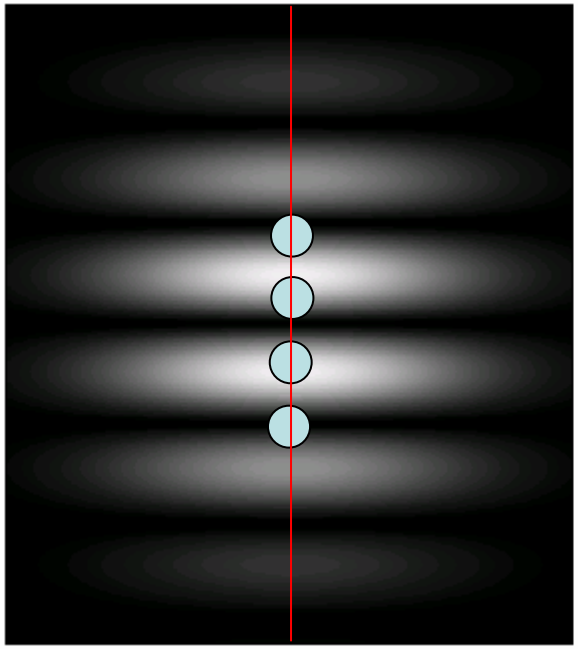


We measure distances along measurement lines using two techniques:

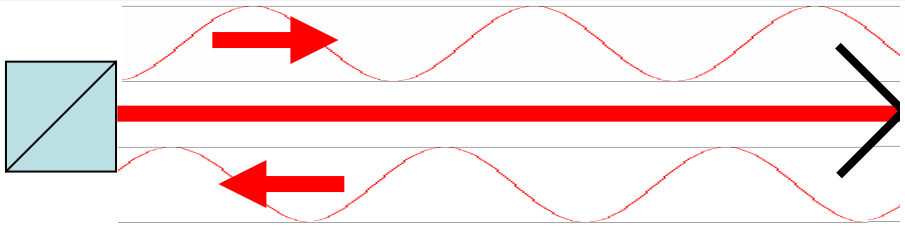
- Absolute distance interferometry
- Displacement interferometry

Each line is the same, and is capable of performing both types of measurement.

Interferometer operation



Interferometer operation



Phase = 2π (Optical Path Distance) / Wavelength

$$\theta = 2\pi D / \lambda$$
$$= 2\pi D (v / c)$$

$$\Delta D = (c/2\pi v)\, \Delta\theta$$

Fixed Frequency Interferometry

$$D = (c/ 2\pi)\, (\Delta\theta/\Delta nu)$$
$$R = (c/ 2\pi)\, (\Delta\Phi/\Delta nu)$$
$$D = R\, (\Delta\theta/\Delta\Phi)$$

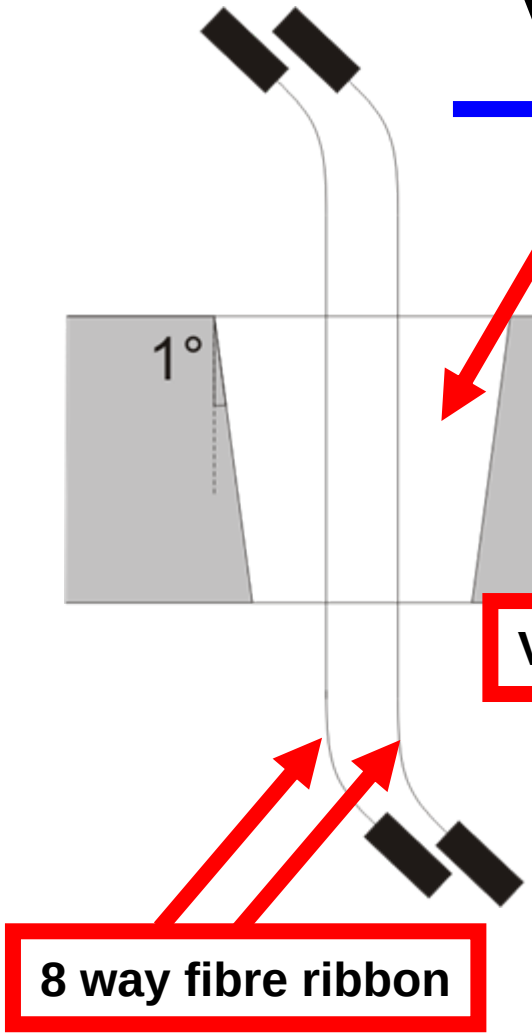
Frequency Scanning Interferometry

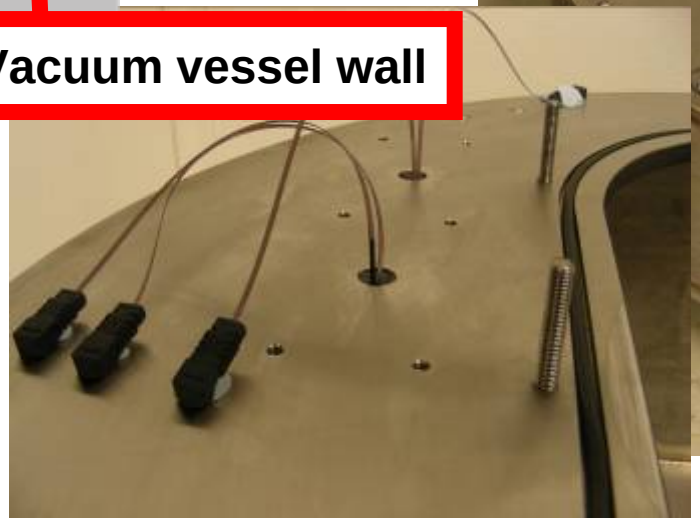
Current Status

Fixed Frequency Interferometry

- Must reach low level of uncertainty for:
  - Laser frequency
  - Refractive index

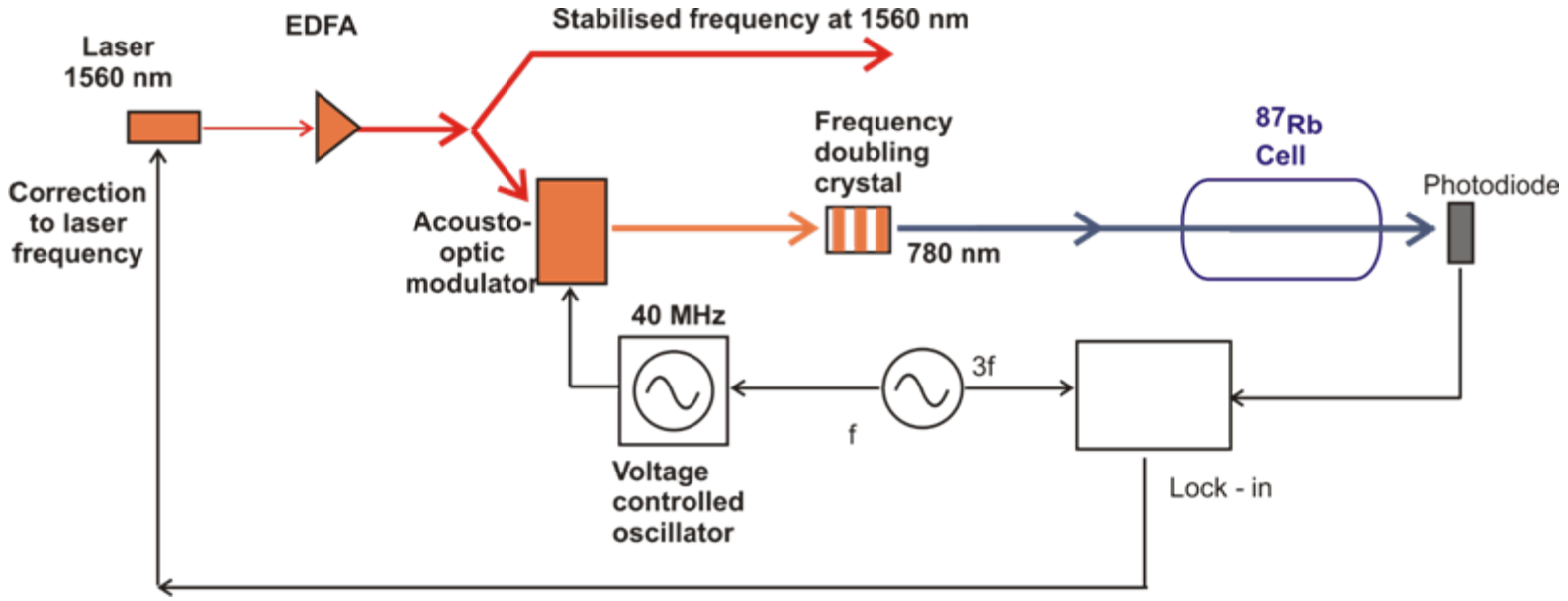
Vacuum System





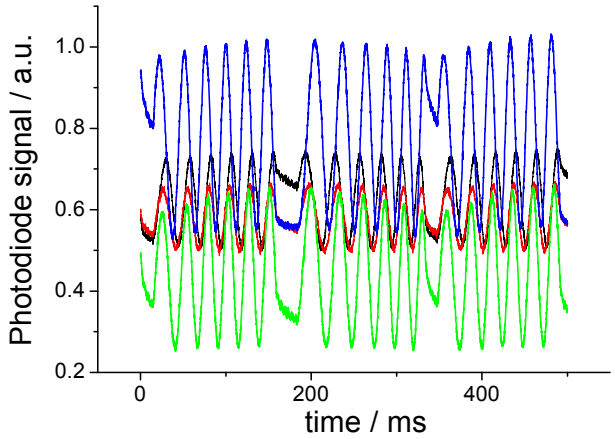
Frequency Stabilisation

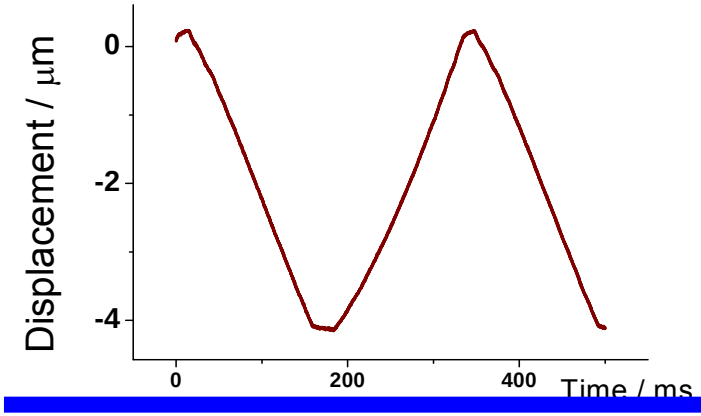
- Lock laser to spectral feature of rubidium
- Use a frequency doubling crystal to reach this frequency



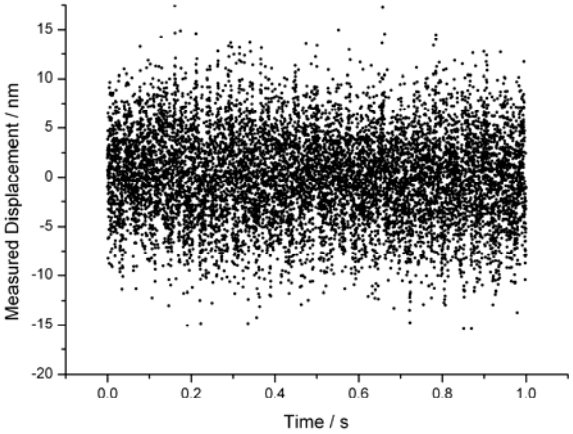
Fixed Frequency Interferometry

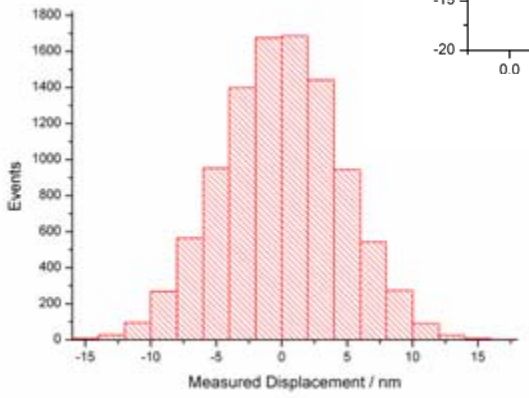
Motion measurement





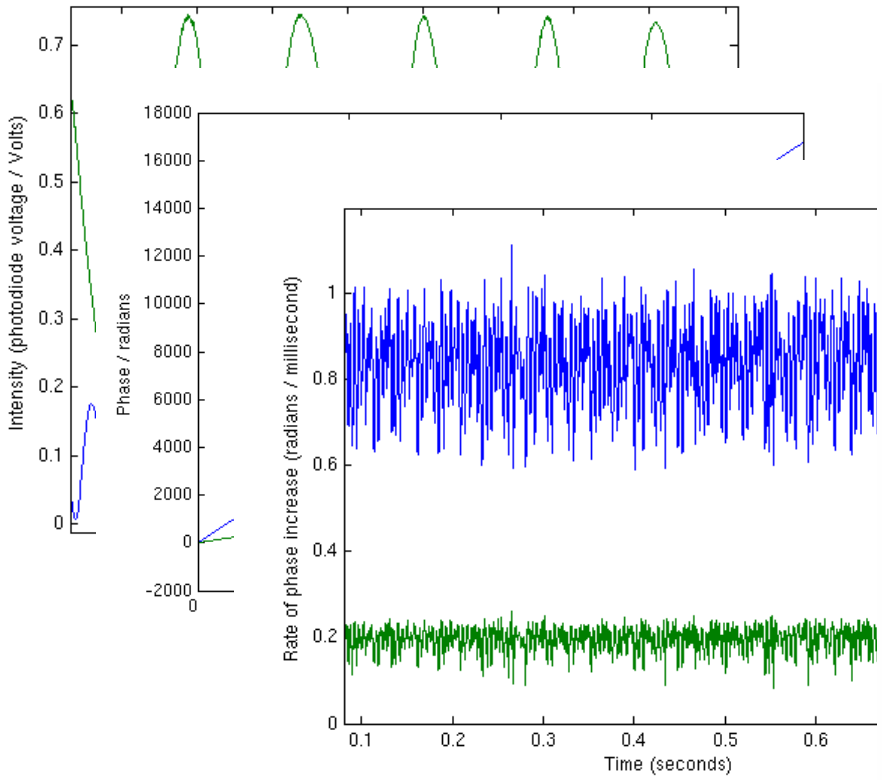
Repeatability measurement

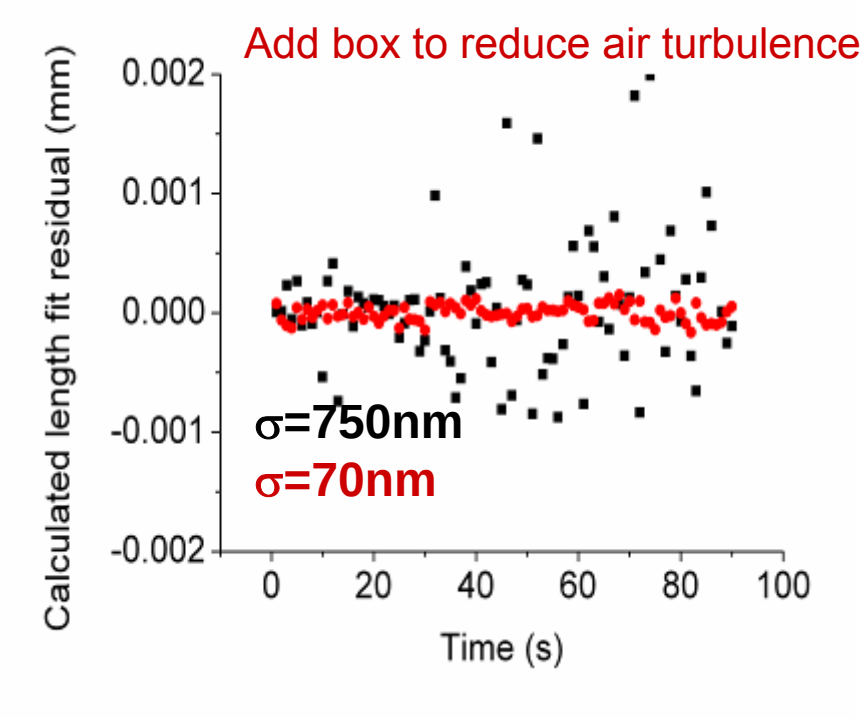




Measurement at 400mm distance

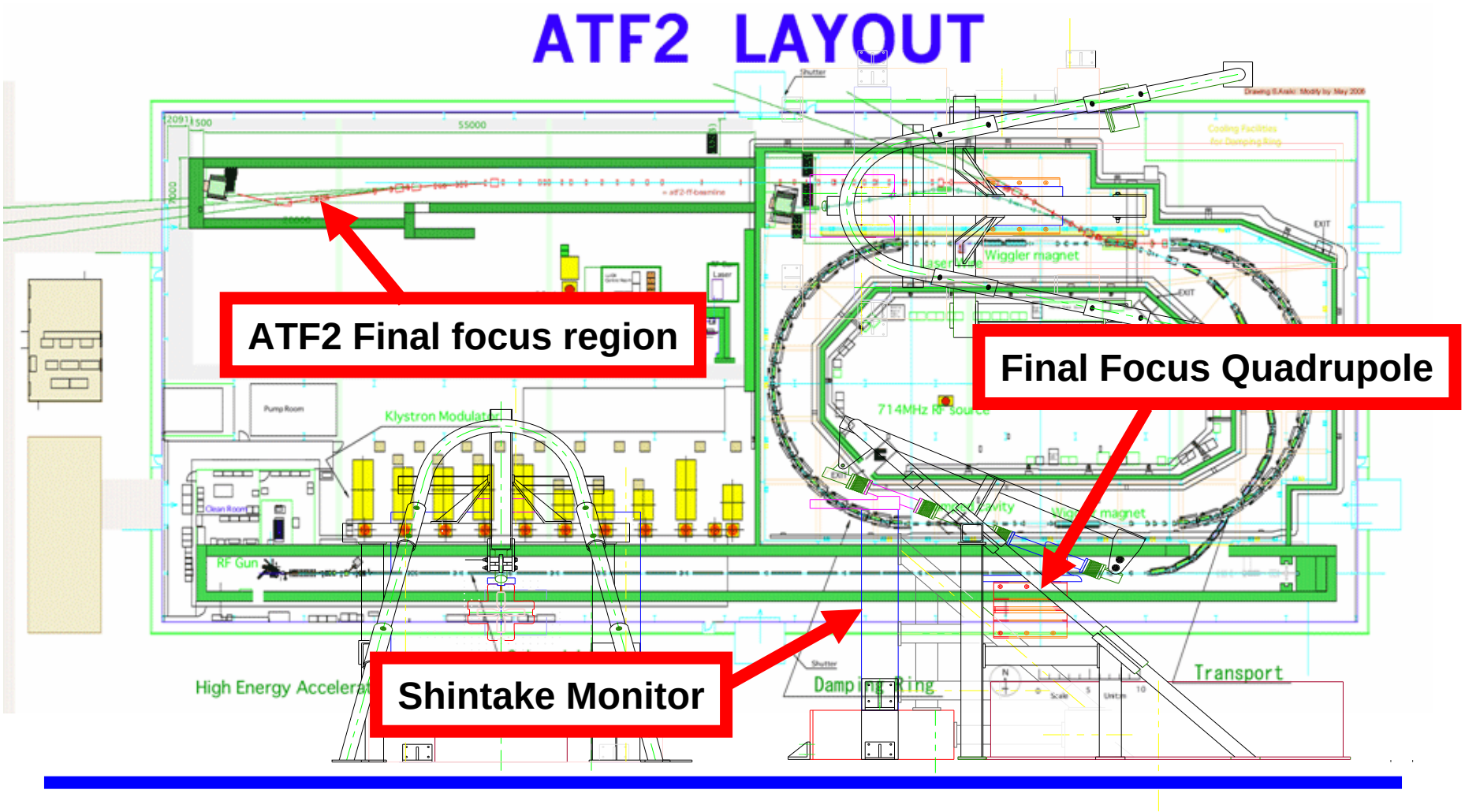
Frequency Scanning Interferometry





Measurement over 400mm distance

Operation at KEK



Summary

- Strict alignment tolerances for ILC final focus quadrupoles
- Optical metrology to help with
  - Inter-train measurements; with FFI
  - Between runs / push-pull operations; with FSI
- Current status
  - 5nm FFI resolution (at 400mm distance)
  - 70nm FSI resolution (at 400mm distance)
- Future
  - Reduce uncertainties with vacuum and laser stabilisation for FFI and dual laser scanning for FSI
  - Test a full system in an accelerator environment at KEK