Monitoring Alignment & Stabilisation with high Accuracy

MONALISA an Update

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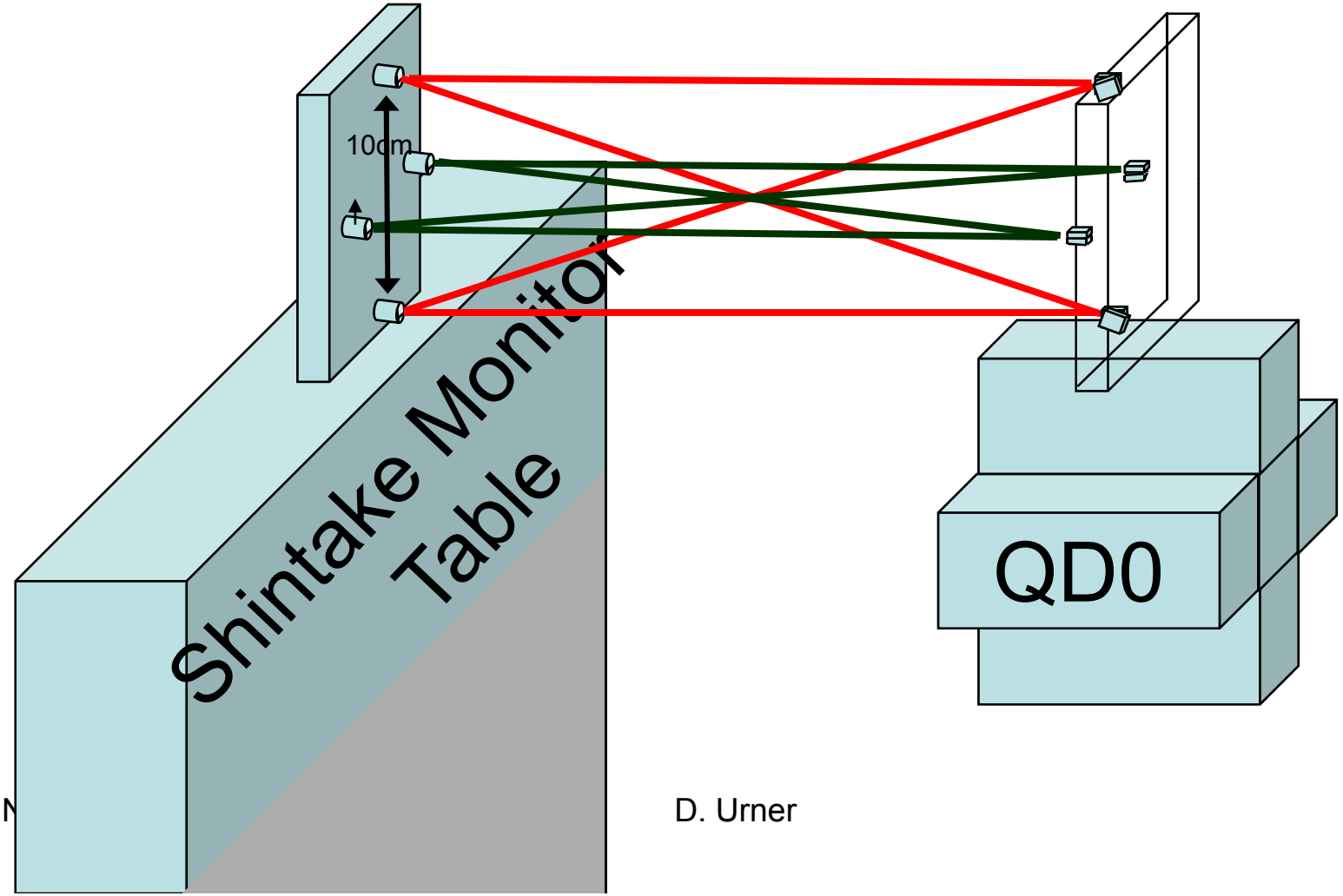
MONALISA

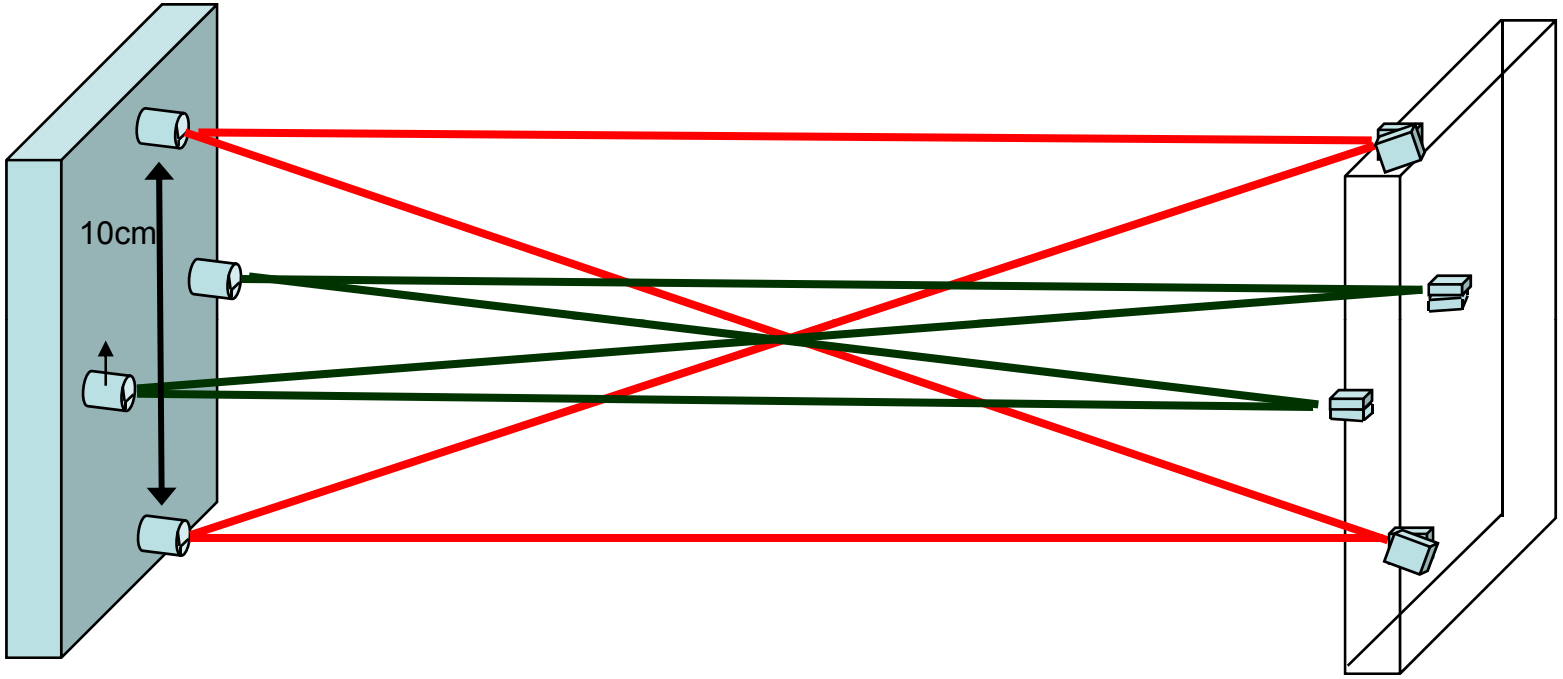
- Is an interferometric metrology system for continuous monitoring of position critical accelerator components
- Consists of a fixed network of evacuated interferometric distance meters

Concepts

Compact Straightness Monitor
Very Schematic View of ATF2 Setup

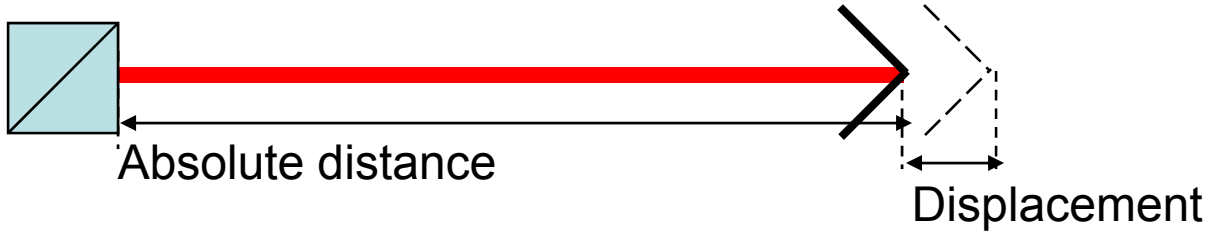


Compact Straightness Monitor



- 6D position transferred from left to right
  - breaking of symmetries is important
- Preliminary simulation results of CSM Resolution:
  - σ_y:10nm
  - distance meter resolution: 1nm = Resolution in z-direction
  - Positional change of optics components with respect to each other: 1nm. That's the challenge!

Measurement lines

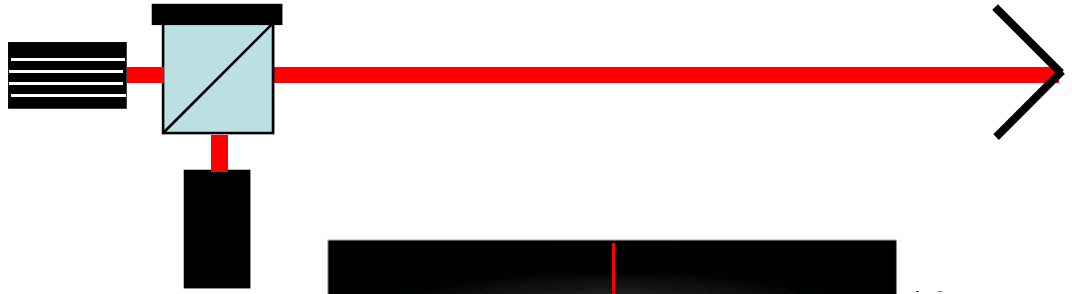


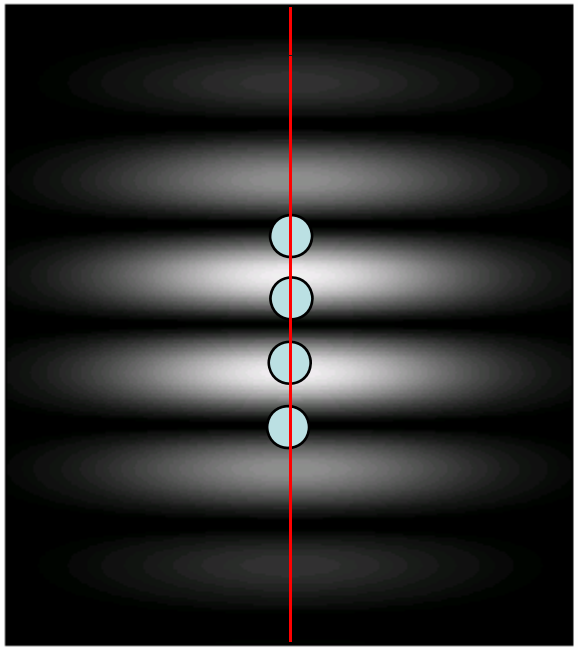
We measure distances along measurement lines using two techniques:

- Absolute distance interferometry <μm resolutions
- Displacement interferometry nm resolutions

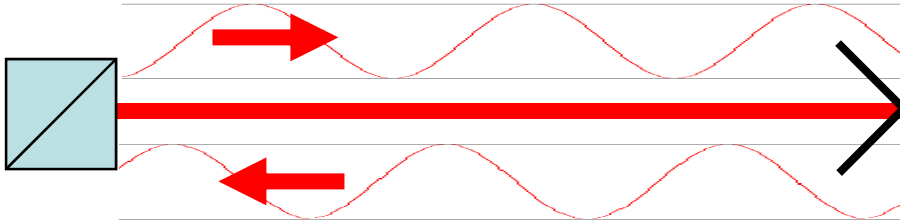
Each line is the same, and is capable of performing both types of measurement.

Interferometer operation





Interferometer operation



Phase = 2π (Optical Path Distance) / Wavelength

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

frequeny scanning

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

Fixed Frequency Interferometry

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

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

$$D = R\,(\Delta\Phi/\Delta\theta)$$

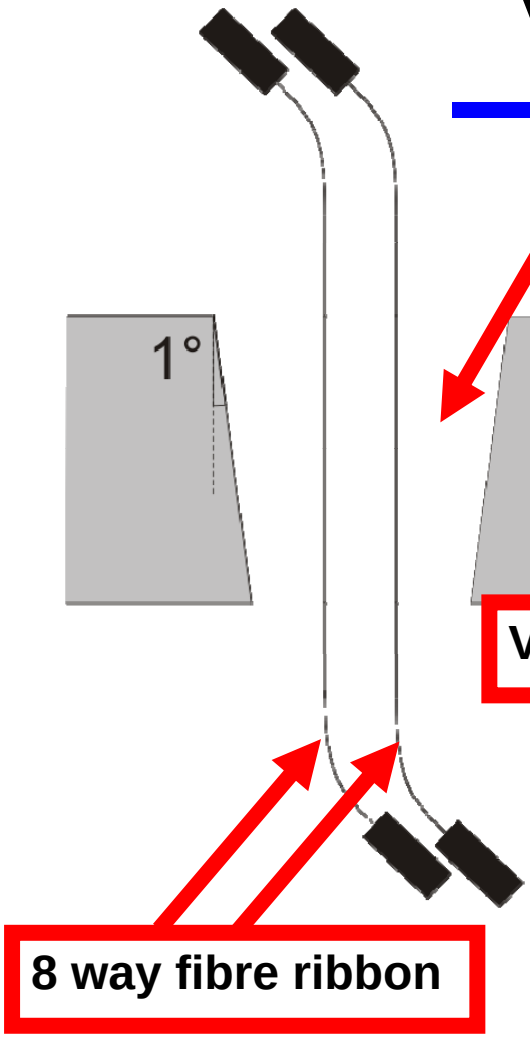
Frequency Scanning Interferometry

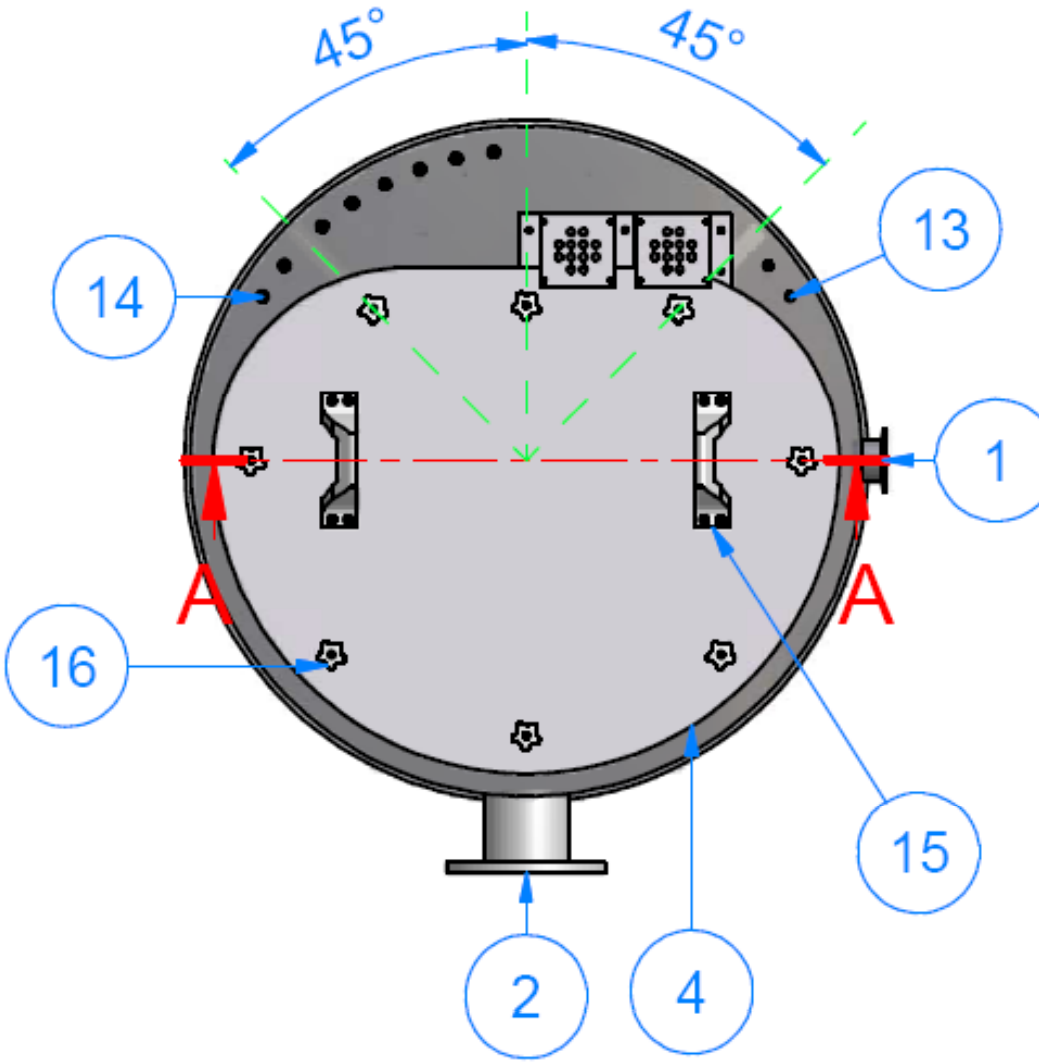
Distance meter

- Measurement Frequencies:
  - FFI: up to 10kHz
  - FSI: up to 1Hz
- Long term stability determines low frequency behaviour
  - Minutes possible
  - Lot of work needed to extend to hours or days.
- Advantage of interferometric measurement system is fairly low cost per line.
  - Use of telecom frequency allows use of cheap commercial hardware
  - Cheap amplification of light
  - Current estimate: as low as £800 per distance metre

Current Status

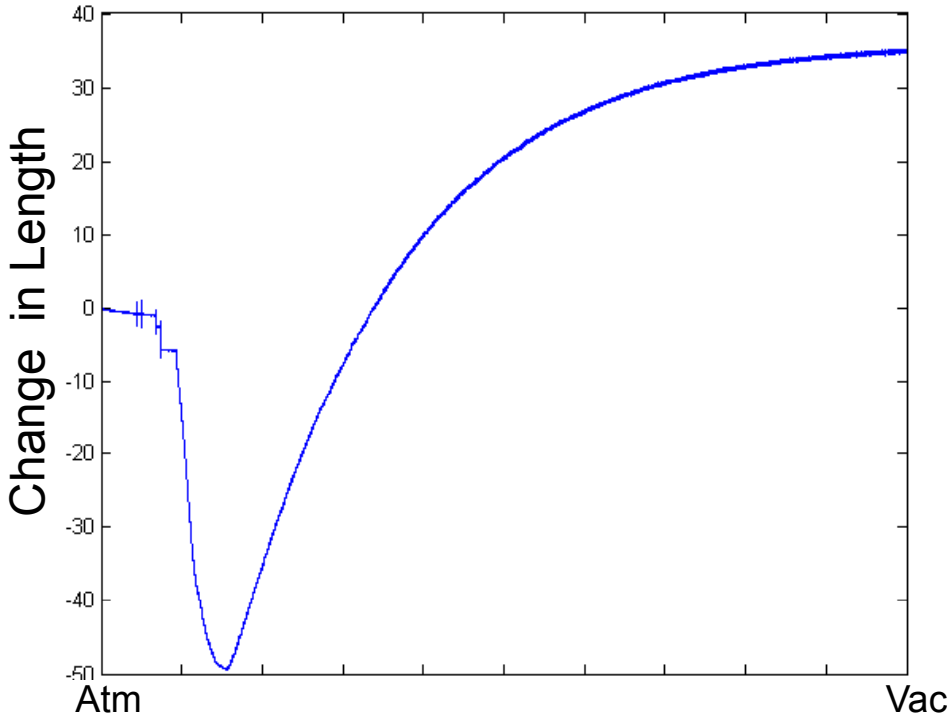
Vacuum System

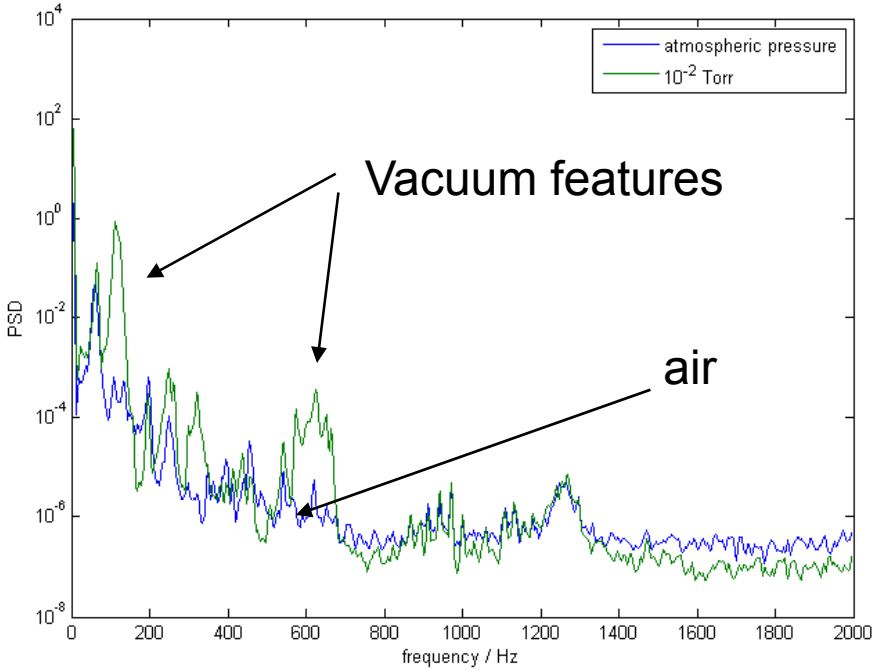




First Measurements in Vacuum

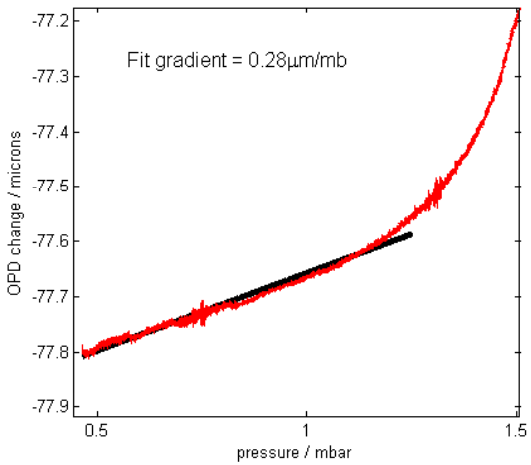
- Unexpected mechanical behaviour
- Tensioning of a drum
  - more mechanical vibrations in vacuum
  - Hard to separate these from resolution effects
- Need for vibration isolation and possibly damping

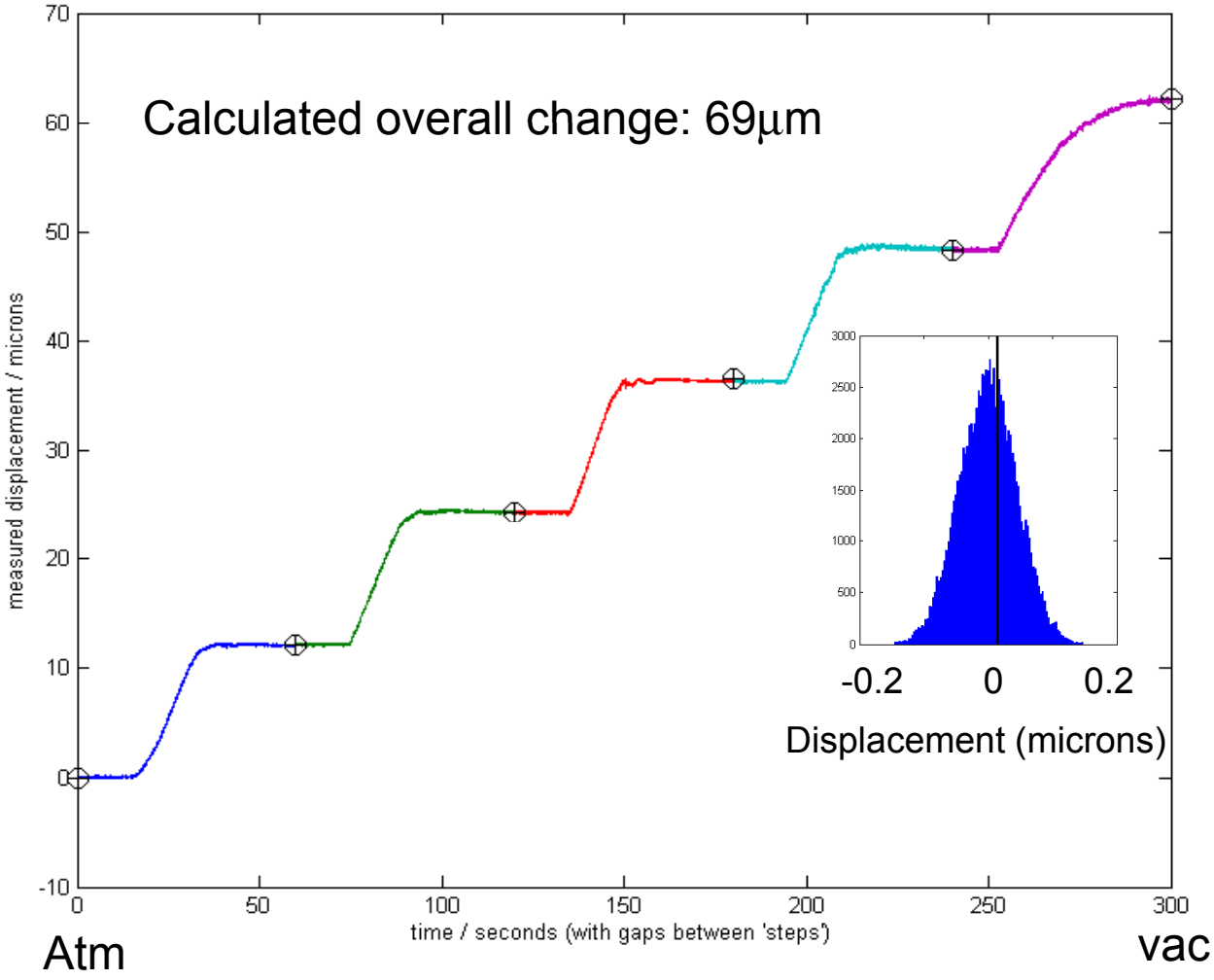




Changing Pressure

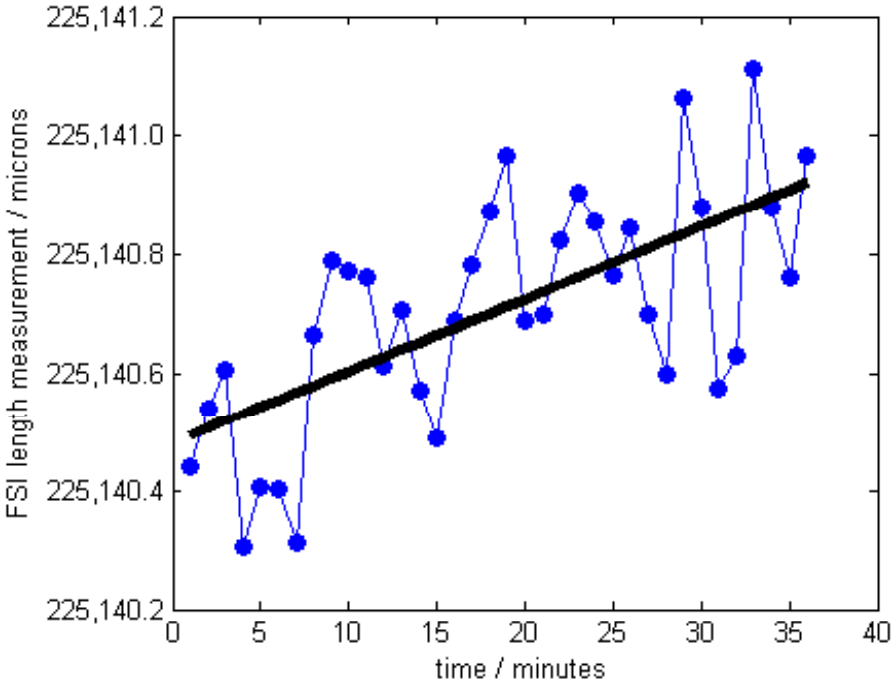
- Good agreement between FSI and FFI
- Decent correlation between pressure and measured OPD

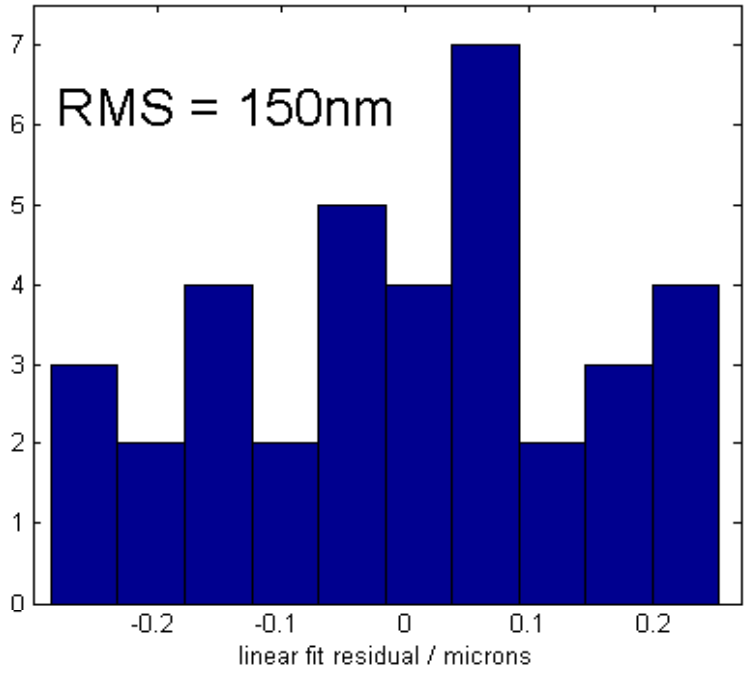




FSI

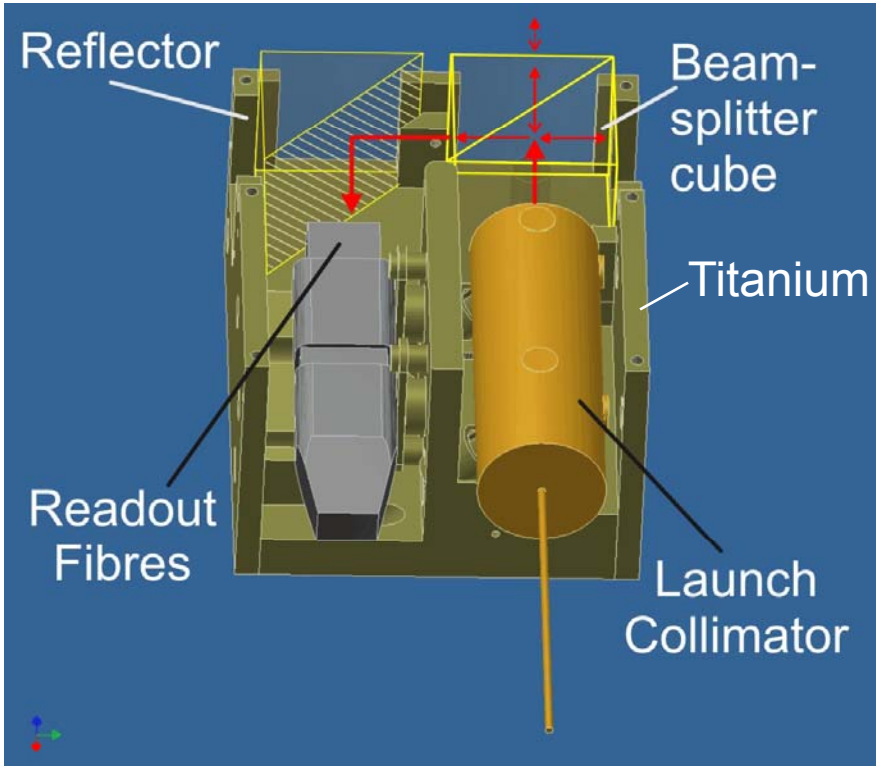
- Dominated by actual vibrations!
  - Need damping
  - Need better launch head



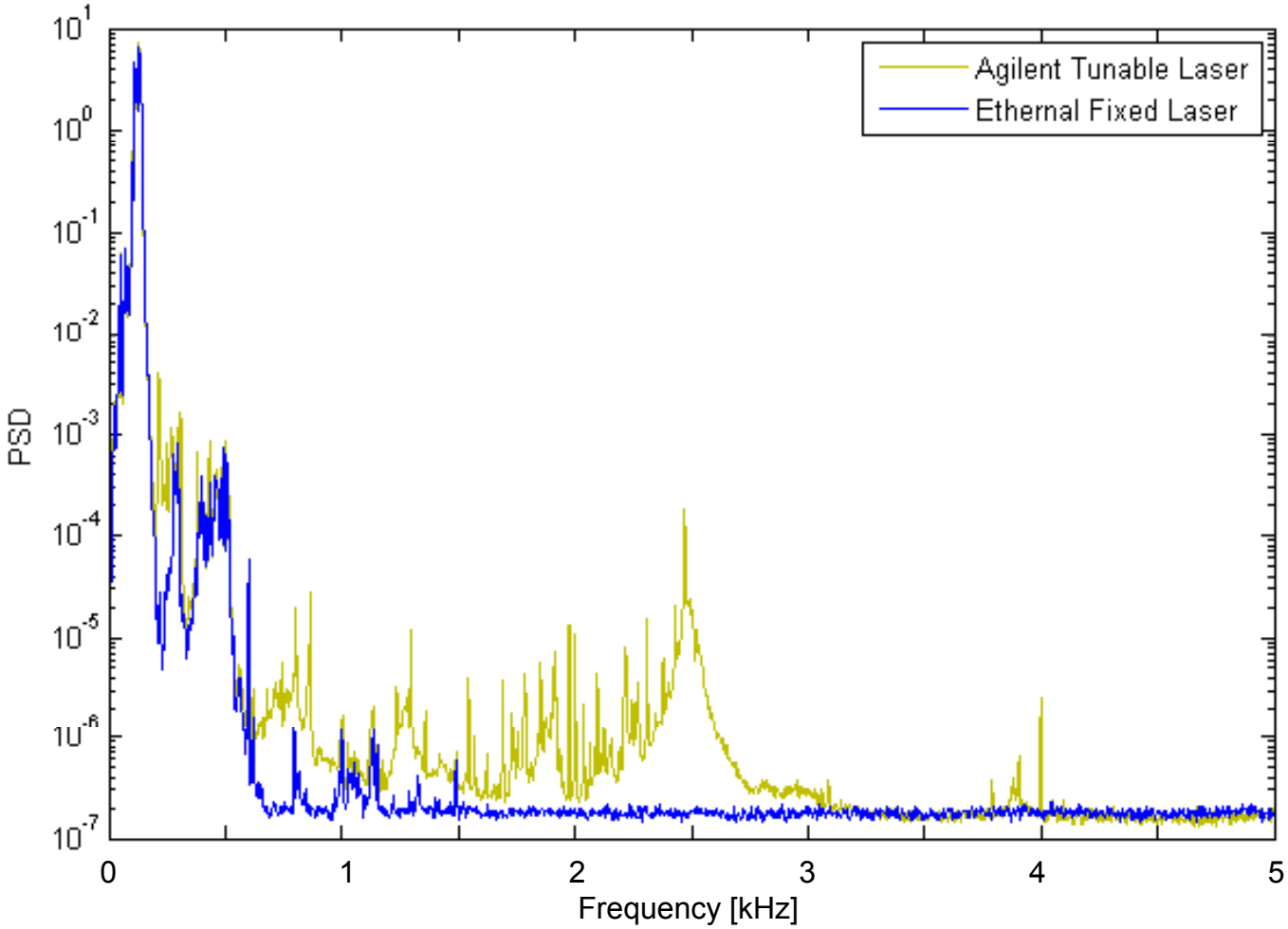


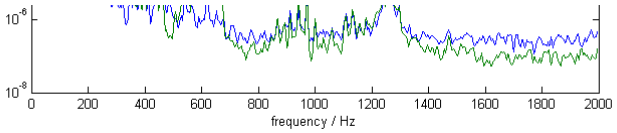
Compact Launch Head

- Launch Head needs following features:
  - Compact
  - Stable/rugged
    - Temperature
    - Vibrations
  - Cheap
- Prototype:
  - Adjustable
  - Currently being built
- Future: Jig to position
  - Glue components onto substrate



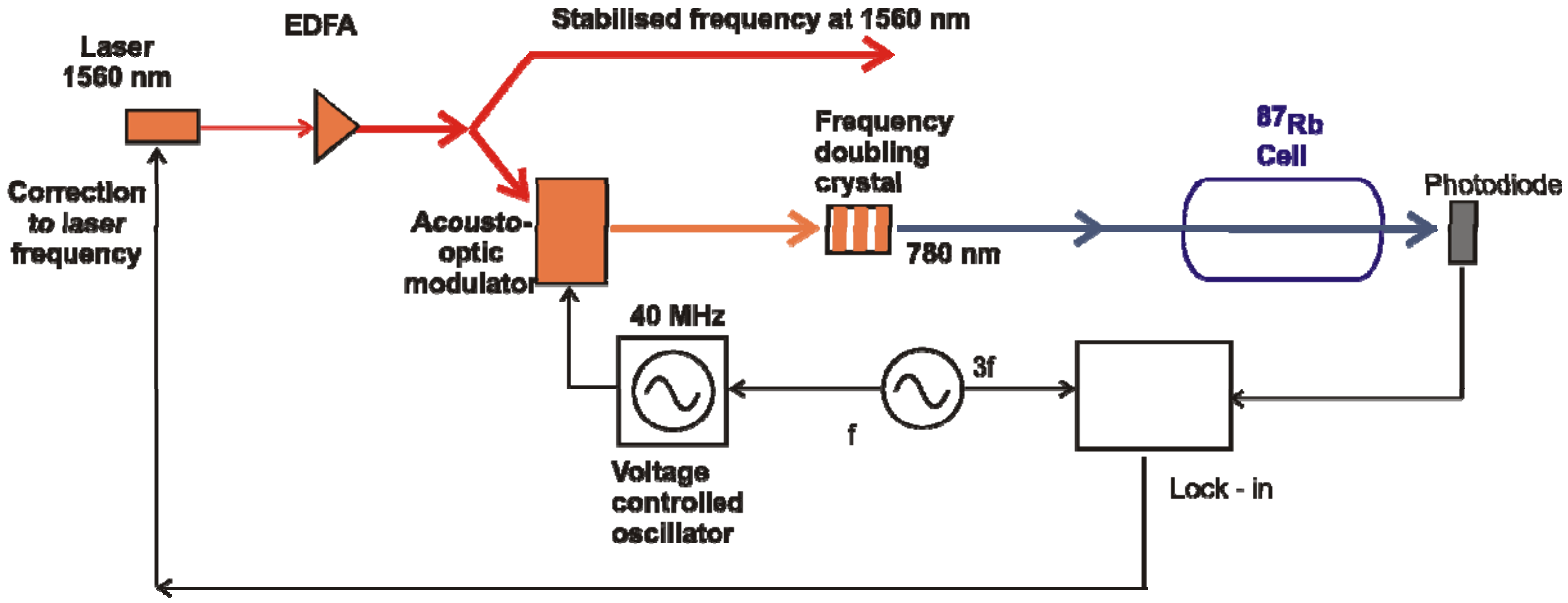
Fixed Frequency Interferometry





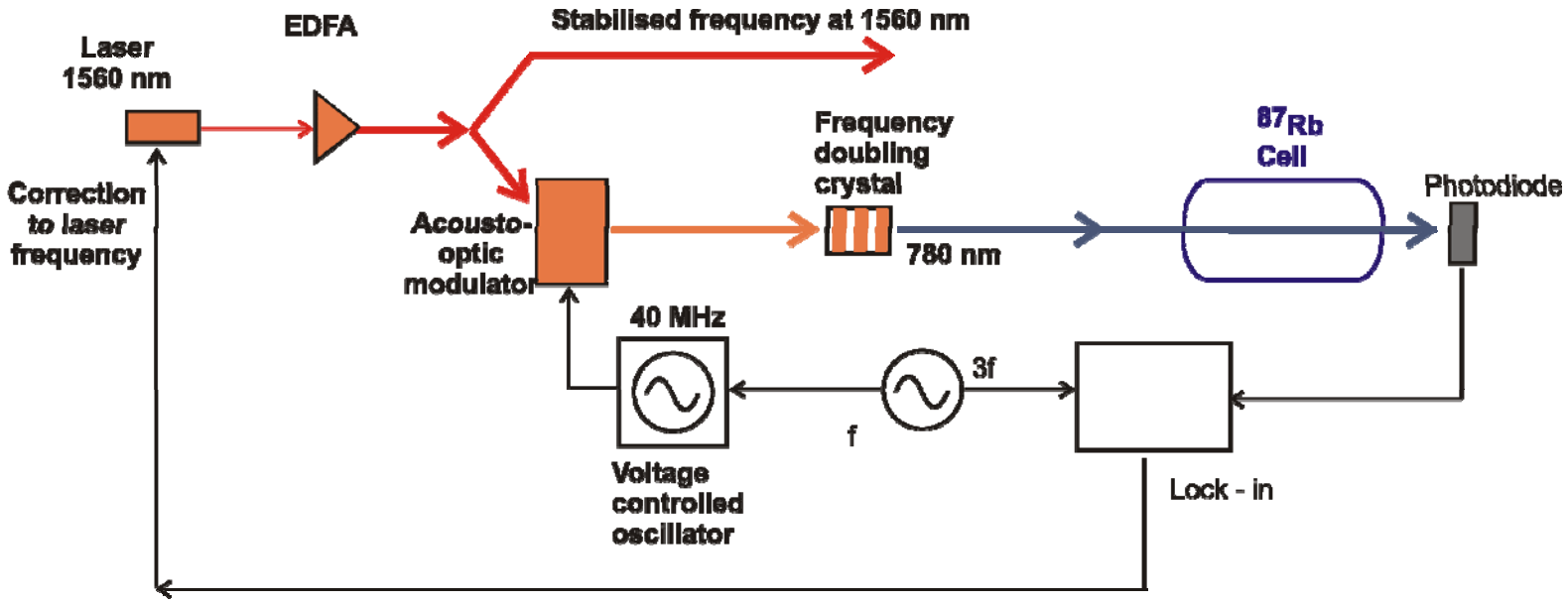
Frequency Stabilisation

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



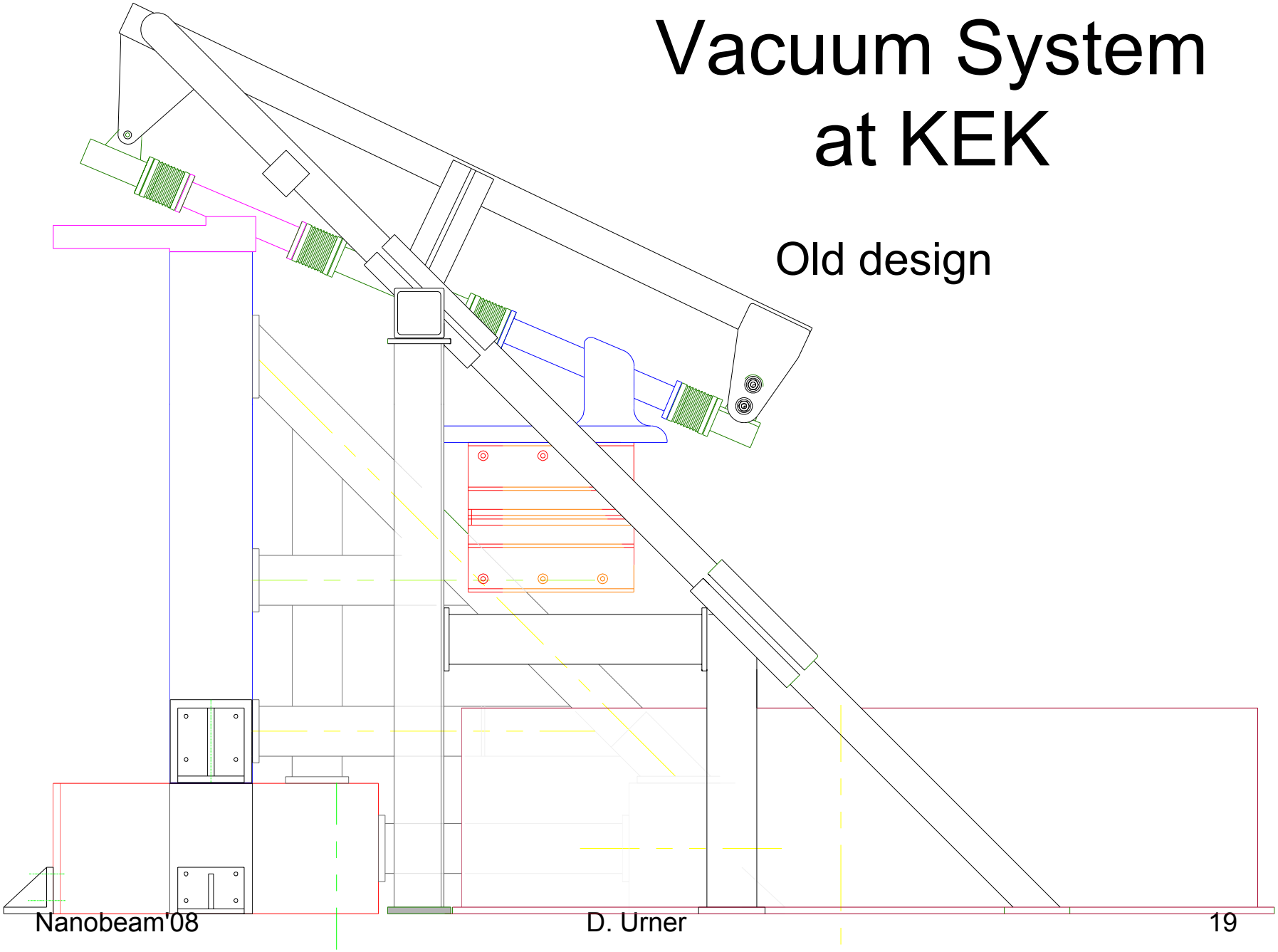
Frequency Stabilisation

- All parts are at Oxford
- Mechanical assembly in progress

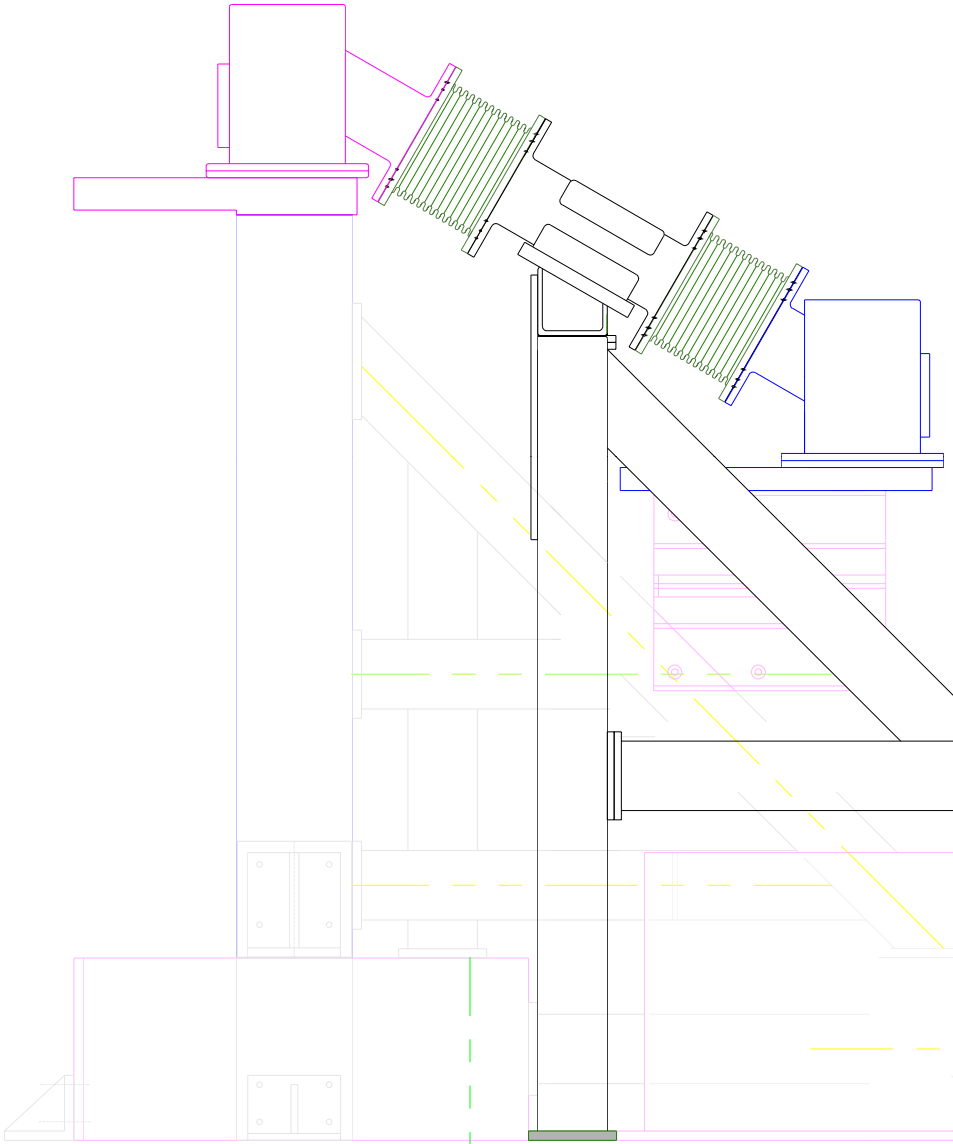


Vacuum System at KEK

Old design



Vacuum System at ATF2

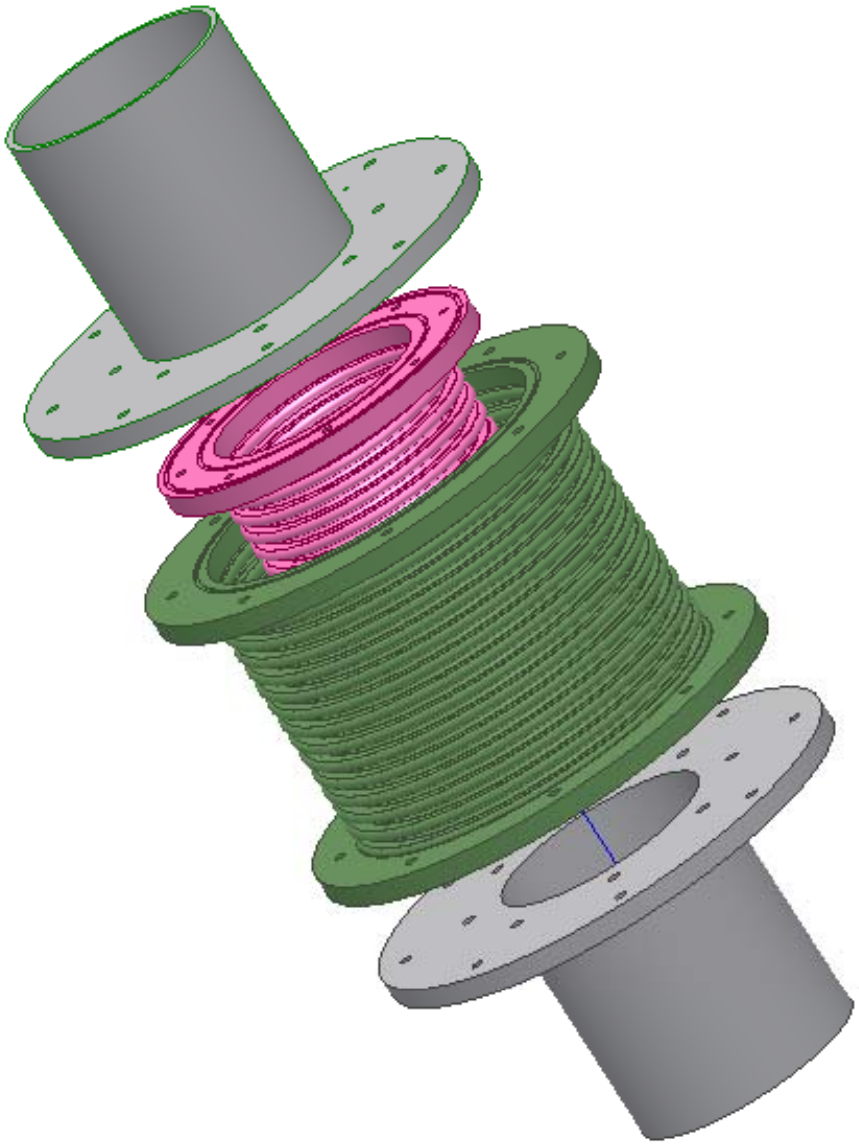


New Design

Double bellow system:

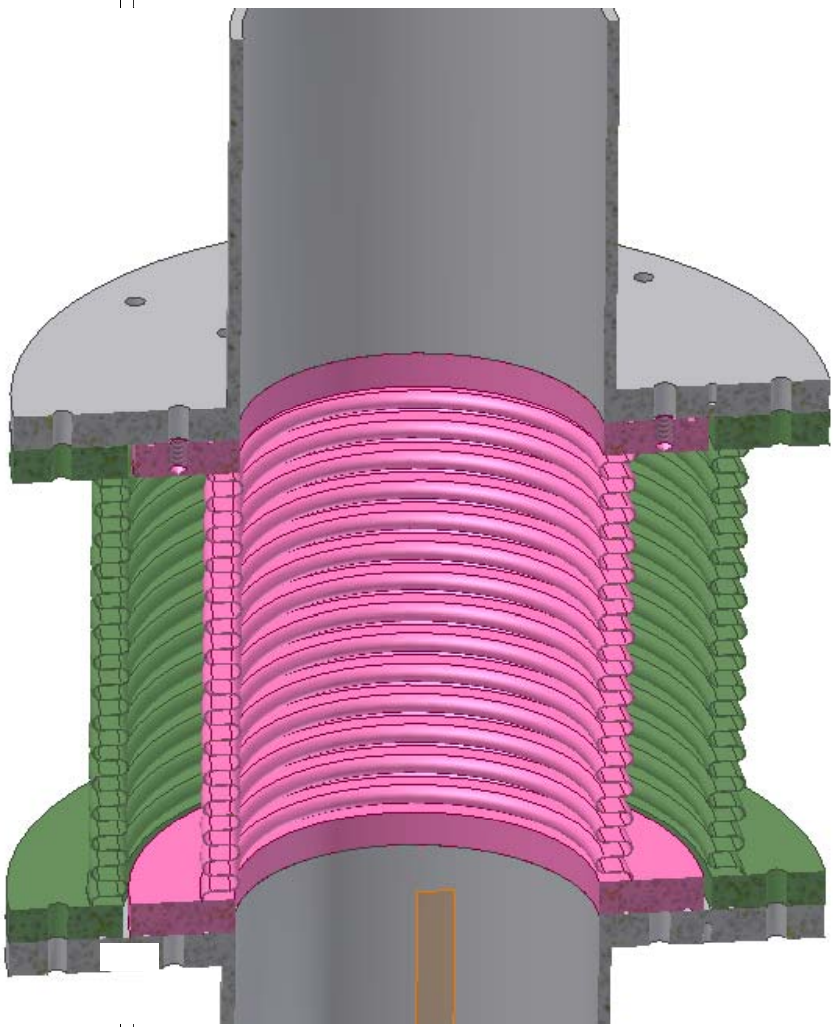
- Advantage:
  - smaller frame
- Disadvantage:
  - active feedback
  - slightly less good compensation of forces

Double bellow system:



Active feedback:

- measure pressure in inner and outer bellow chamber
- stabilize sum of pressures



Summary

- Very first measurements in vacuum
- Compact Launch Head
- Frequency Stabilization
- Vacuum System for ATF2