Monitoring Alignment & Stabilisation with high Accuracy

MONALISA

Position monitoring around the IP

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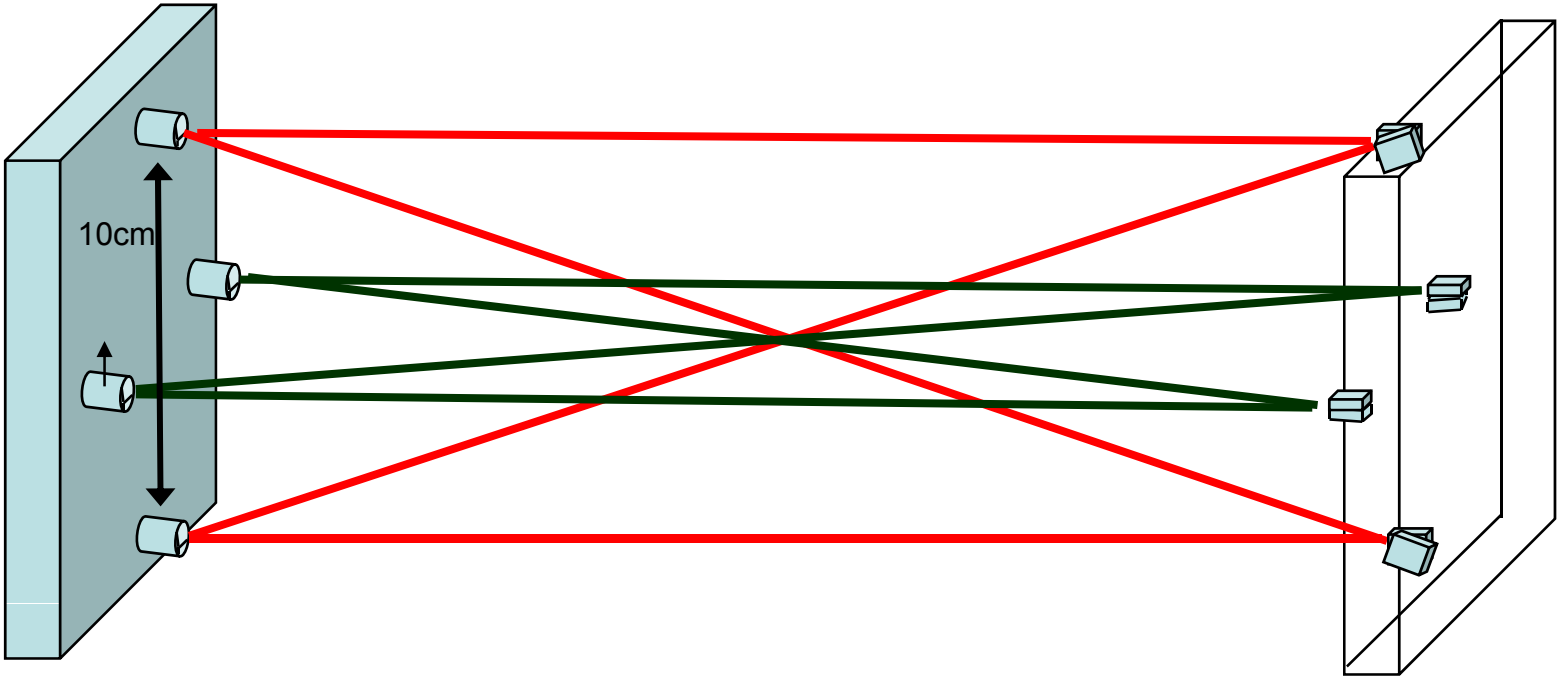
MONALISA

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

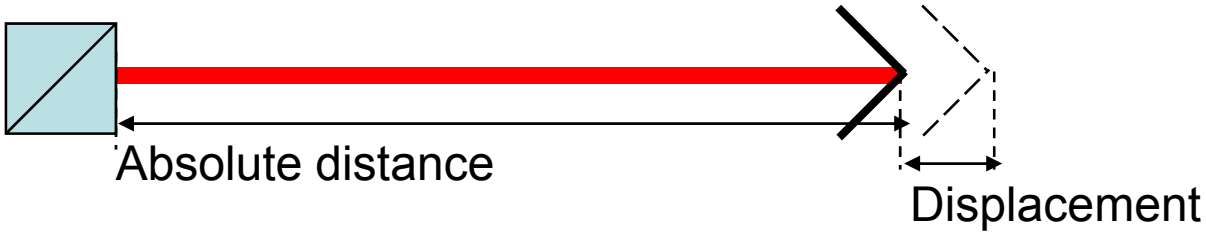
Concepts

Compact Straightness Monitor



- 6D position transferred from left to right
  - Integral use of sturdy endplates required.
- 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

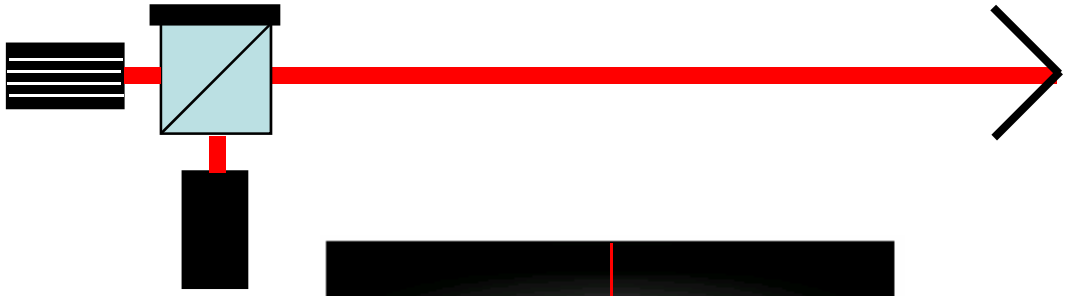


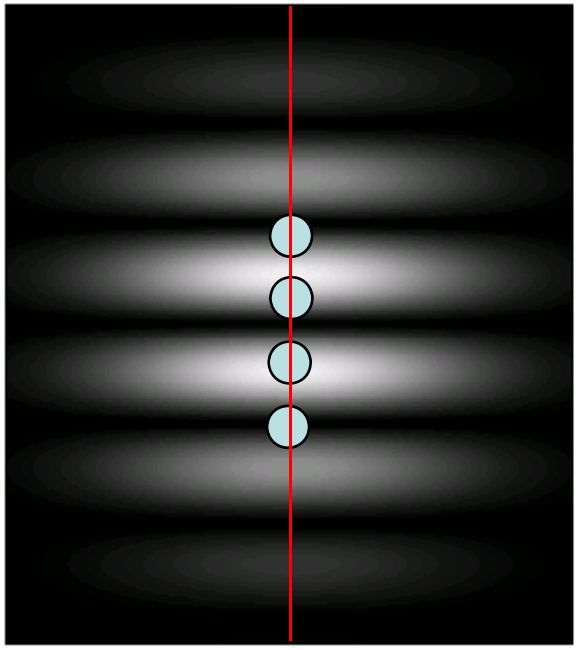
We measure distances along measurement lines using two techniques:

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

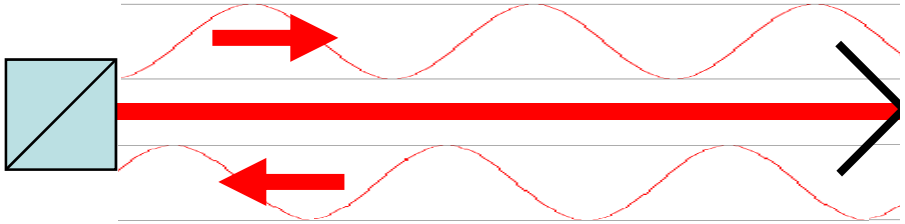
Each line is the same, and is capable of performing both types of measurement.

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

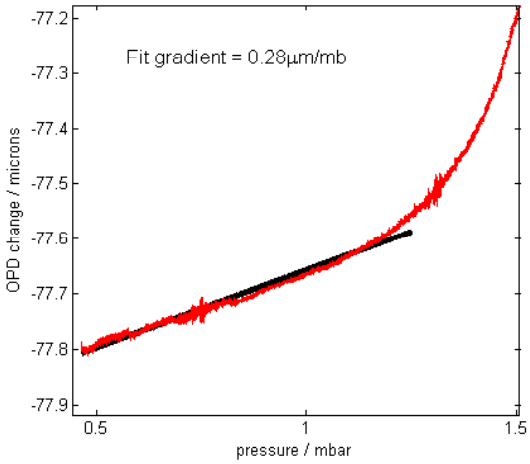
Distance meter

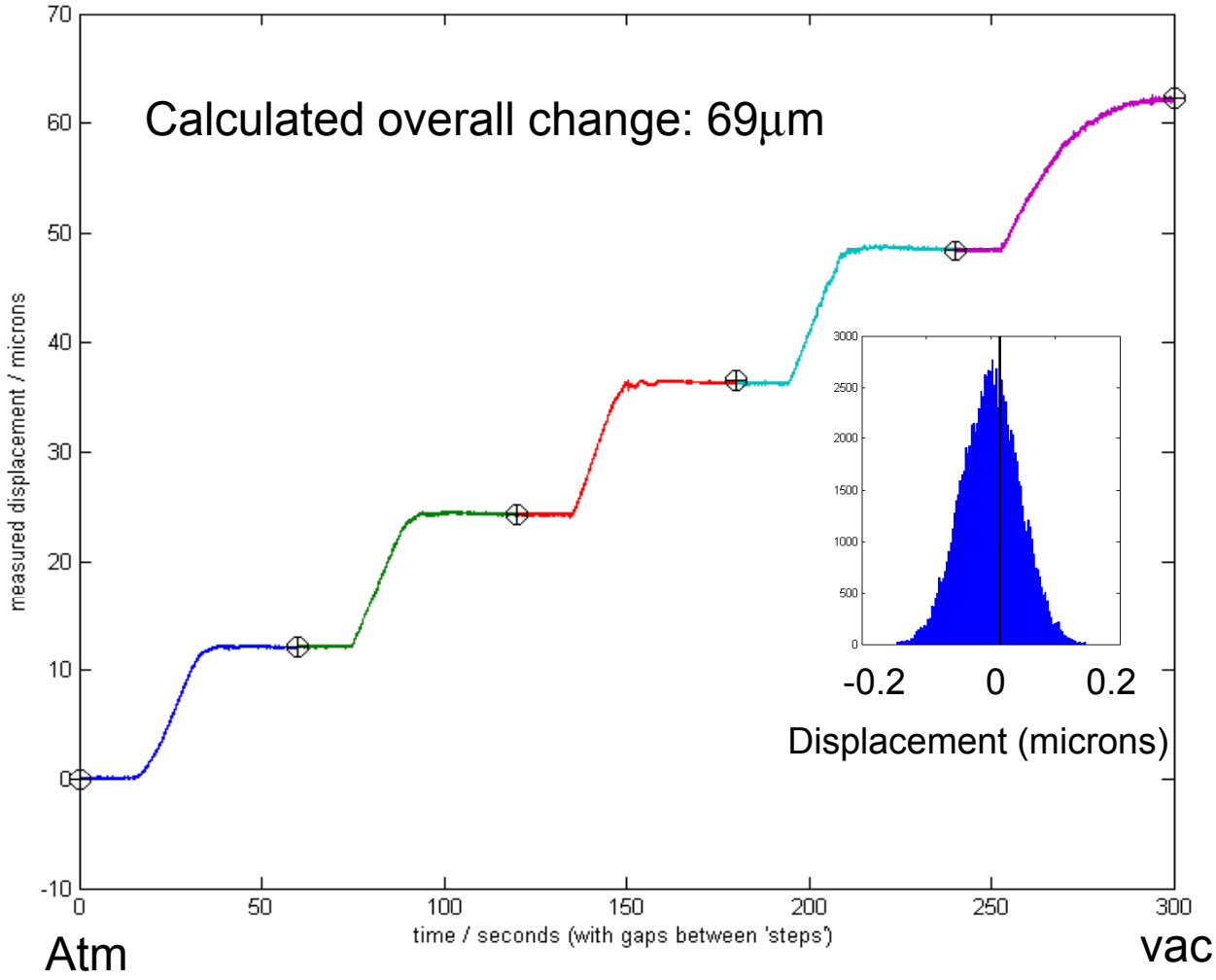
- Measurement Frequencies:
  - FFI: up to 10kHz
  - FSI: up to 1Hz
- Long term stability determines low frequency behaviour
  - Minutes possible
  - Lot of work needed to extend to hours or days.
- Advantage of interferometric measurement system is fairly low cost per line.
  - Use of telecom frequency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

Current Status

Changing Pressure

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





Position monitoring around the IP

Beam based feedback

- Is essential for ILC, CLIC
- Survey and initial alignment required.
- Working alignment needs to be maintained / restored.
  - between trains
    - 200 ms is long enough for several 100 nm movement
  - Take into account long term drifts
  - after push-pull events:
    - IR hall floor will move after rolling two heavy detectors
  - after shutdown periods
- A cheap position monitoring system of critical elements is your friend.

MONALISA: Benefits

Monitoring fiducial locations on key components

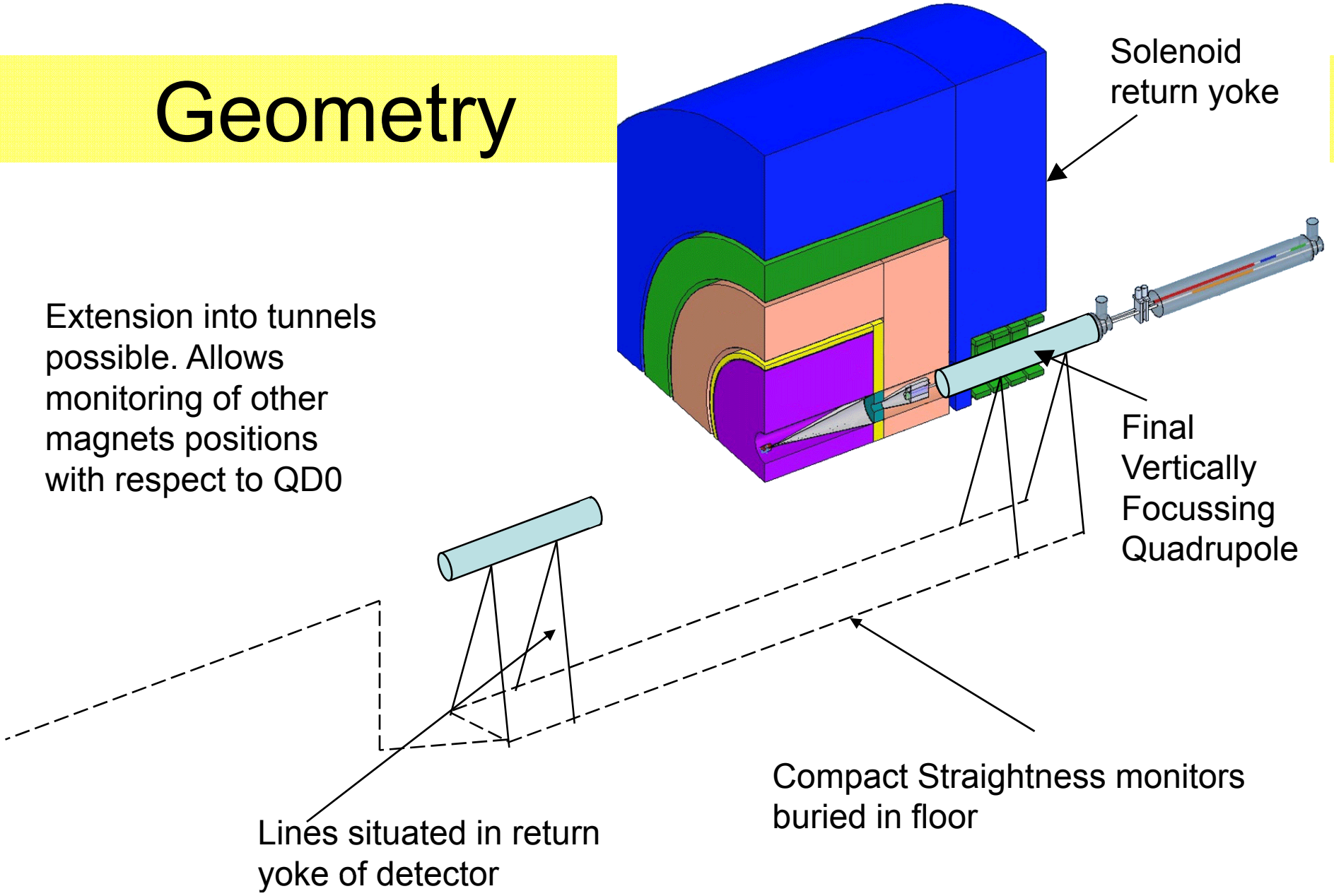
- after interruption of beam
  - independently follows changes in alignment
- during commissioning / start up
  - improves understanding of machine behaviour
- before accelerator operation
  - speeds up initial convergence of machine

MONALISA: Benefits

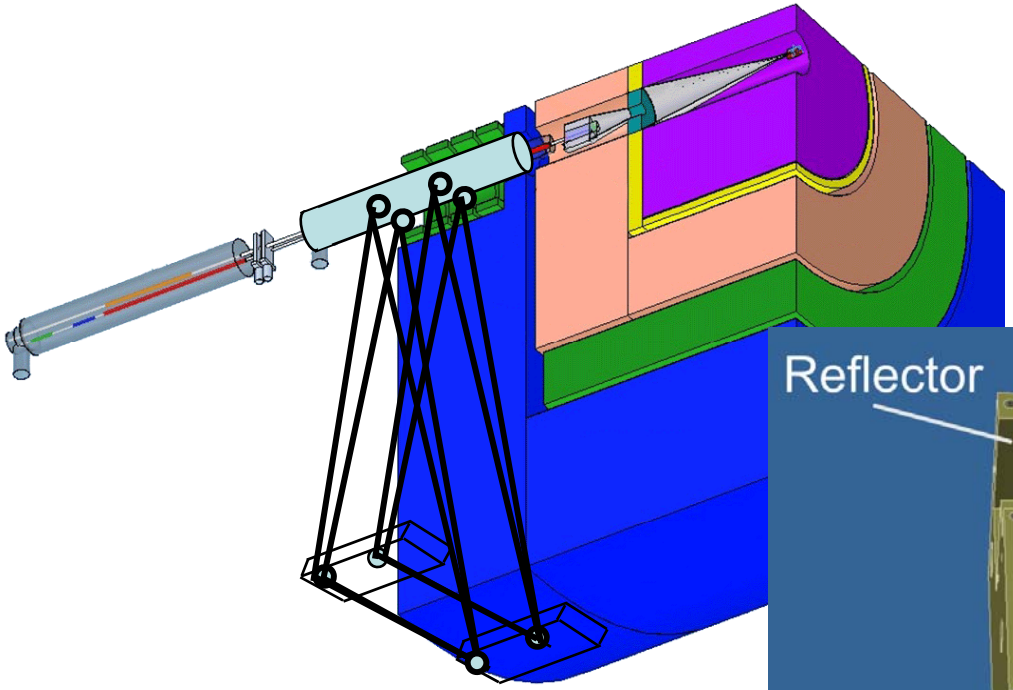
Return detector / QDzero position after push-pull

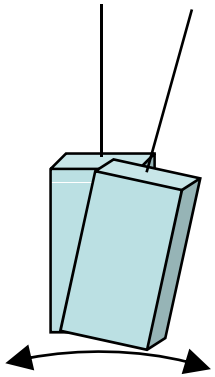
- expect to get micron repeatability
  - for return of magnet positions
  - but compared to which location?
- get machine within beam based capture range
  - improves switchover time
- more reliable accelerator operation
  - lower chance of damage
  - luminosity can only win

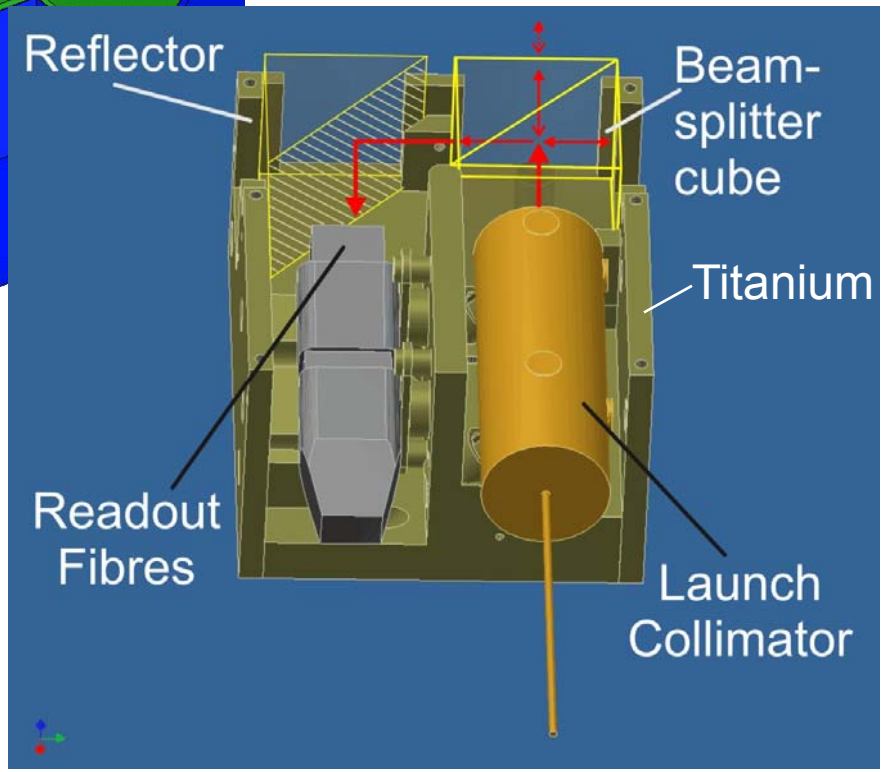
Geometry


Solenoid return yoke
Extension into tunnels possible. Allows monitoring of other magnets positions with respect to QD0
Final Vertically Focussing Quadrupole
Compact Straightness monitors buried in floor
Lines situated in return yoke of detector

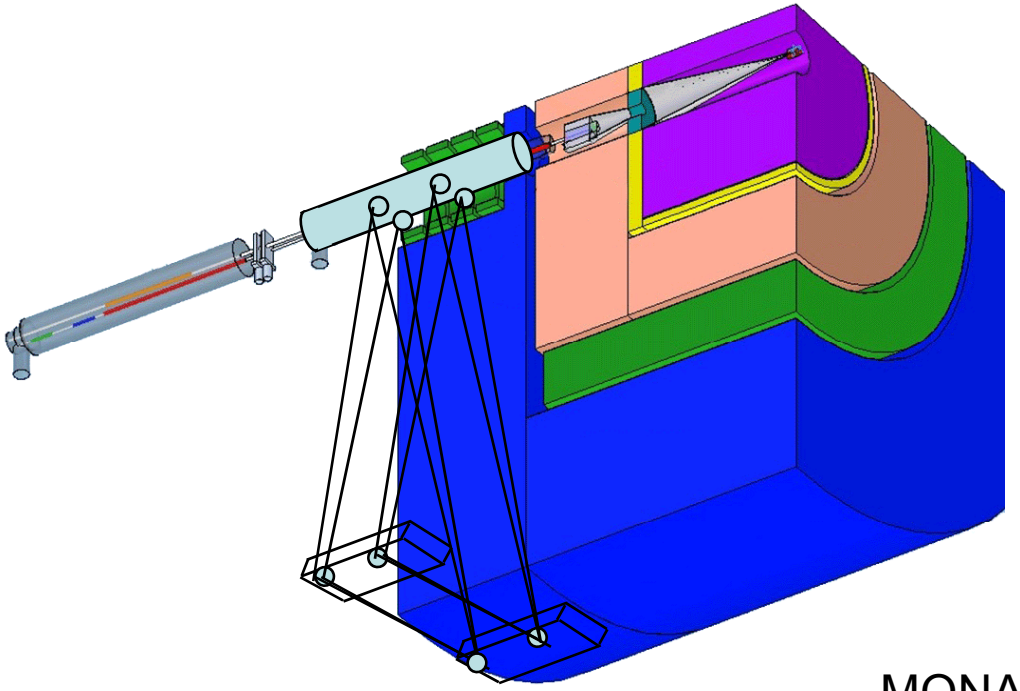
Straightness Monitors Attached to Detector



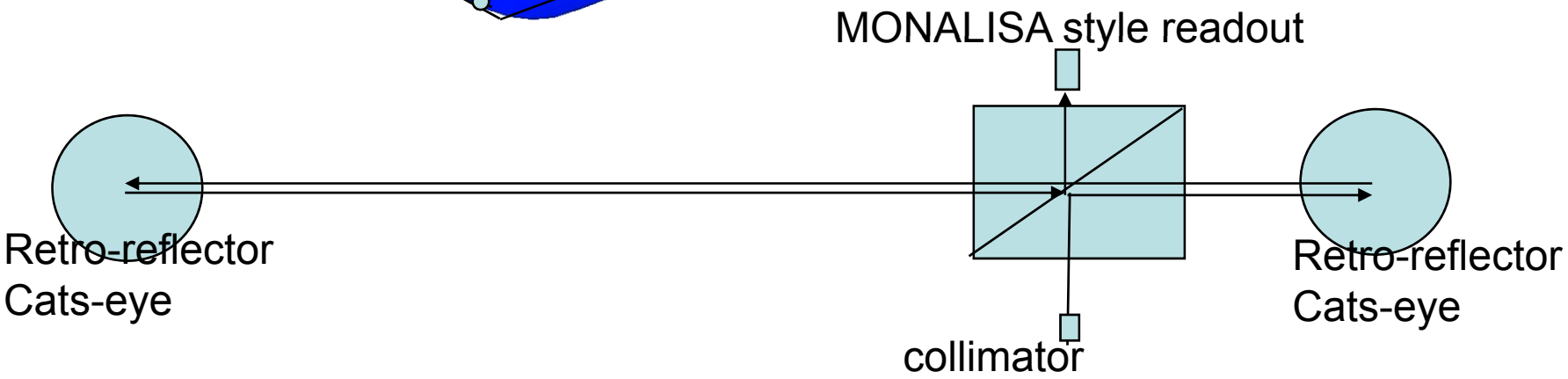




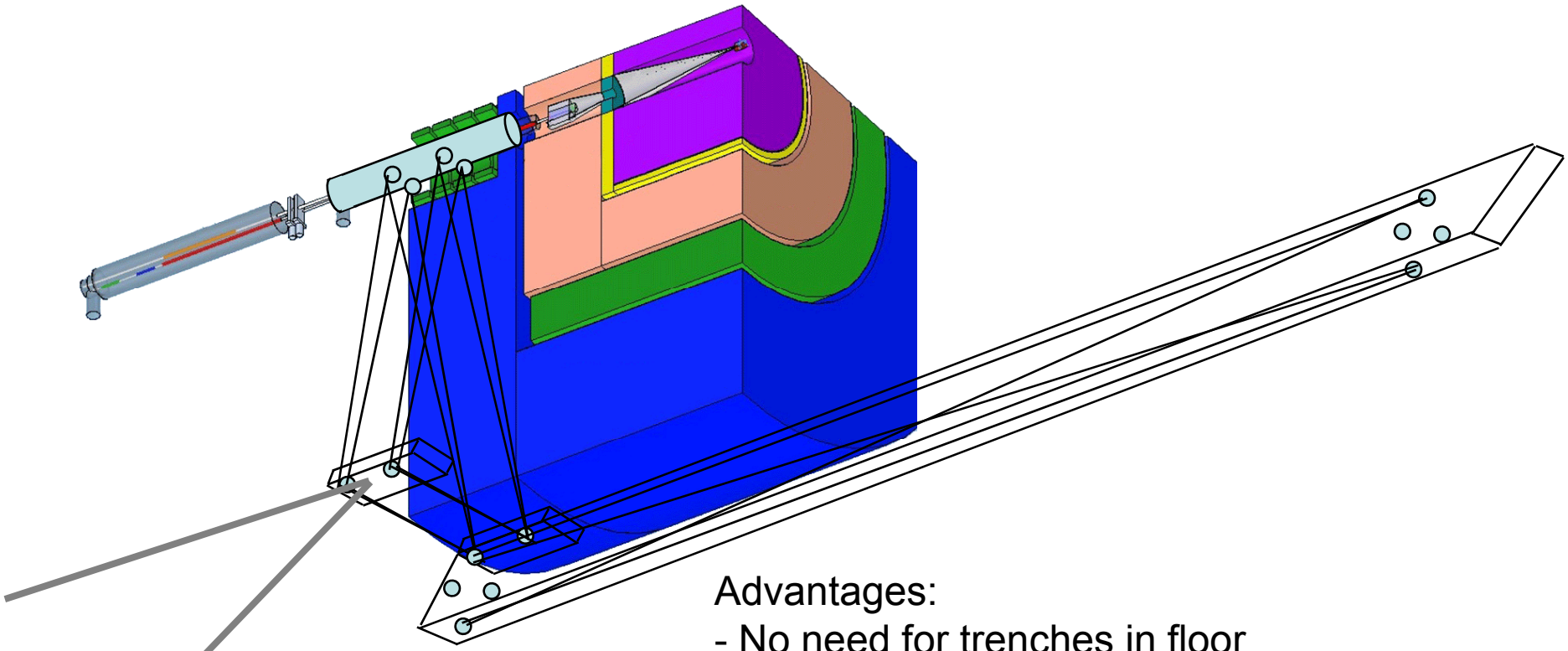
Straightness Monitors Attached to Detector



Double cats-eye system:
- Measures between 2 points
- Allows for larger networks of interferometers
-Transfer platform needs not to be angularly stable.
- Requires a lot of R&D



Straightness Monitors Attached to Detector



MONALISA lines to floor/wall
- Through air
- Order 1 micron absolute resolution
  good enough for repositioning detector

Advantages:
- No need for trenches in floor
- Solves difficulty with ultra-stable platform

Just an idea: System can be used to monitor distortion of magnet during push-pull
- Could be expanded

Summary

- MONALISA is an interferometric metrology system for continuous monitoring of position critical accelerator components
- Monitor position of QD0's in the nanometre regime.
- Inexpensive enough to monitor a large variety of critical beam line elements
- Requires lines of sight through return yoke of magnets endcap.