Design and Measurements on Chambers for Horizontal Offset Mirrors for the European XFEL

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Introduction

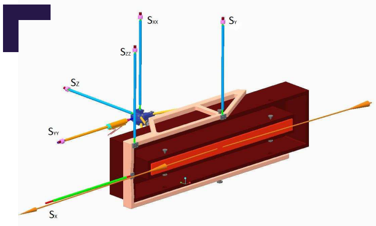
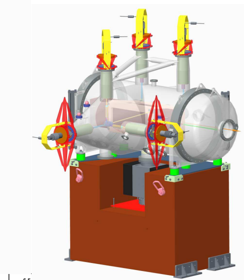
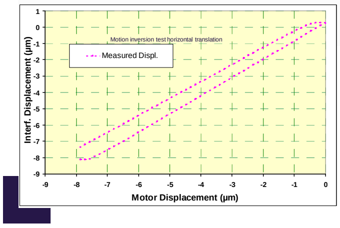
The offset and distribution mirrors of the beam distribution system of the European XFEL require ultra precise positioning and extreme stability against vibration. A parallel kinematic design was chosen to cover both the large travel ranges and the precise angular positioning. With motors and all rotating parts outside the chamber, the carbon-free UHV requirements could be reached.Two prototype CHOMs were built and tested for their vacuum performance, vibration behaviour and long term stability.

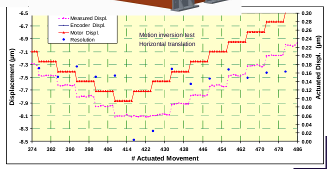
Design Requirements

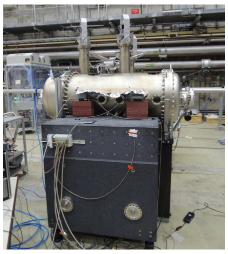
- Horizontal and vertical translation ±40mm
- Pitch and roll angle adjustable with less than 20nrad accuracy
- Vibrations and drift small against beam divergence (2 µrad).
- Long term drift comparable to *optimistic* ground diffusion (110 µm/day in Experiment Hall = 75 nrad/day)
- Same accessible, low maintenance design for all 9 mirror chambers
- Vacuum 10^{-9}mbar or better, carbon-free, particle free.

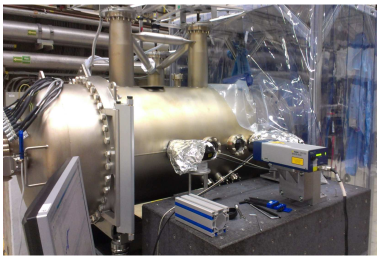
Prototype characteristics

- Parallel kinematic motion system,
- Flexure hinges made from stainless steel rope dampen vibrations
- Easy to calculate and repeatable parasitic motions
- Interferometer measurements at the vendors site already show good accuracy and repeatability
- One prototype was electrochemically polished, to test vacuum perfomance with the smoother surface





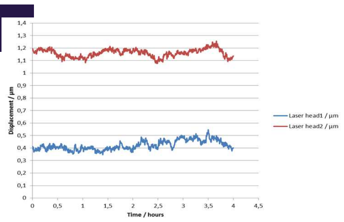


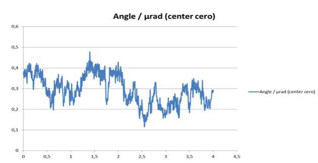

Measurements

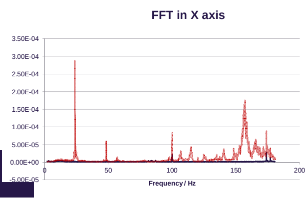
- **Seismometer, Accelerometers:** Ground vibrations and transfer functions floor/granite, granite/chamber, floor/chamber.
  - ➢The granite was mounted on special vibration damping wedges
  - ➢A set up with 3 and 6 wedges was tested
  - ➢Measurements were performed in a lab 26m below ground
- **Double laser interferometer:** Vibration behaviour of mirror dummy, long term angular drift, change of mirror position during pump-down and venting
  - ➢Interferometers mounted on a separate granite, locked to the chamber's granite
  - ➢Pointing through window flanges at the dummy mirror
  - ➢Covered with a styrofoam box during long term measurements
- **Autocollimator:** cross-check interferometer measurements
- **Vibrometer:** vibration behaviour of the chamber.
- **PT100, thermocouples:** correlate thermal drift with variations in position and angle of the mirror.
  - ➢Mounted inside and outside the chamber

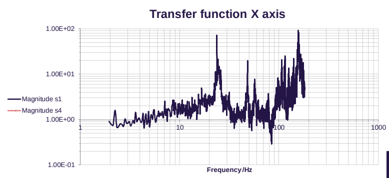
Results

- **Vacuum:**
  the chamber reaches $6{+}10^{-9}$mbar
  RGA shows low concentration of carbohydrates and higher masses
- **Stability**:
  short term measurements 10nm drift (10 - 50sec)
  long term measurements 100nm drift (4hrs)
- **Angular stability**:
  50nrad for short term (10 - 50sec)
  200nrad for long term (4hrs)
- **Vibrations:**
  Major contribution from the floor at around 20Hz and 50Hz
  Transferfunction with 3 wedges >10
  Amplitudes of mirror vibrations 1.75nm@20Hz   2.2nm@50Hz









Conclusion

The prototype fulfills mechanical and vacuum requirements. For the interferometric measurements of mirror drift and vibrations it is crucial to have absolutely stable mounts for the interferometer heads. Thermal variations and ground vibrations cannot easily be filtered from the results. Measurements are performed at the resolution limits of the measurement devices.

Transfer functions of vibrations from ground to mirror chamber pose yet another challenge for the best mounting of granite and CHOM. In the final set up, a specially aligned aluminium plate on epoxy based grouting will be established as base for the granite.