Laser Tracker Test Facility at SLAC

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- Introduction
- Laser Tracker Component Calibration
- Horizontal Angle Tests
- ADM Tests
- Conclusion

Introduction

- *Many physics experiments require very high accuracy positioning, e. g. 100 µm over a distance of 150 m or 25 µm in a 10 x 10 x 3 m volume*
- *Realization -> Laser Tracker Measurements*
- *What do we know about Laser Tracker calibration, e.g.*
  - *Perpendicularity of axes*
  - *Angle measurement accuracy*
  - *Distance measurement accuracy*

Motivation for LT calibration

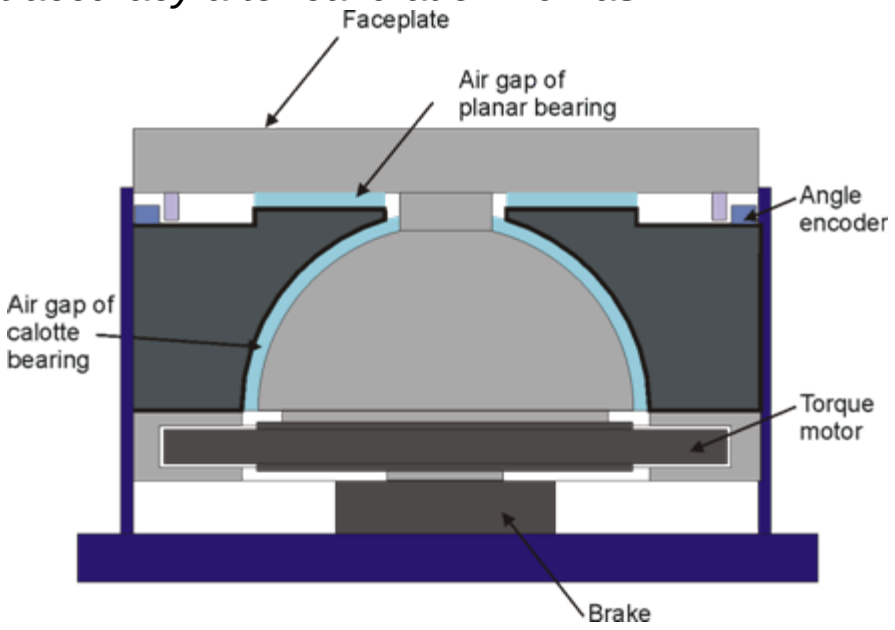
- Laser Tracker is used as a “black box” device
- No known published comprehensive system or component calibration approaches
  - B89.4.19 system calibration procedure is of very limited nature, only 2.3 m base line, < 45 deg angles, angle and distance measurement accuracies correlated
- In contrast, for decades Theodolites and Total Stations were subject of extensive research
  - Literature research creates pages of publication references

Calibration Approach

- *LT system calibration approach quite difficult*
  - *Requires 3D points distributed over LT measurement volume known to higher accuracy than LT measurement*
- *Laser Tracker Component Calibration*
  - *Angle Measurements*
    - *Rotary calibration table with an accuracy of better than 0.2 arcsec*
  - *Distance Measurements*
    - *Interferometer bench, 32m long, HP interferometer, controlled environment*

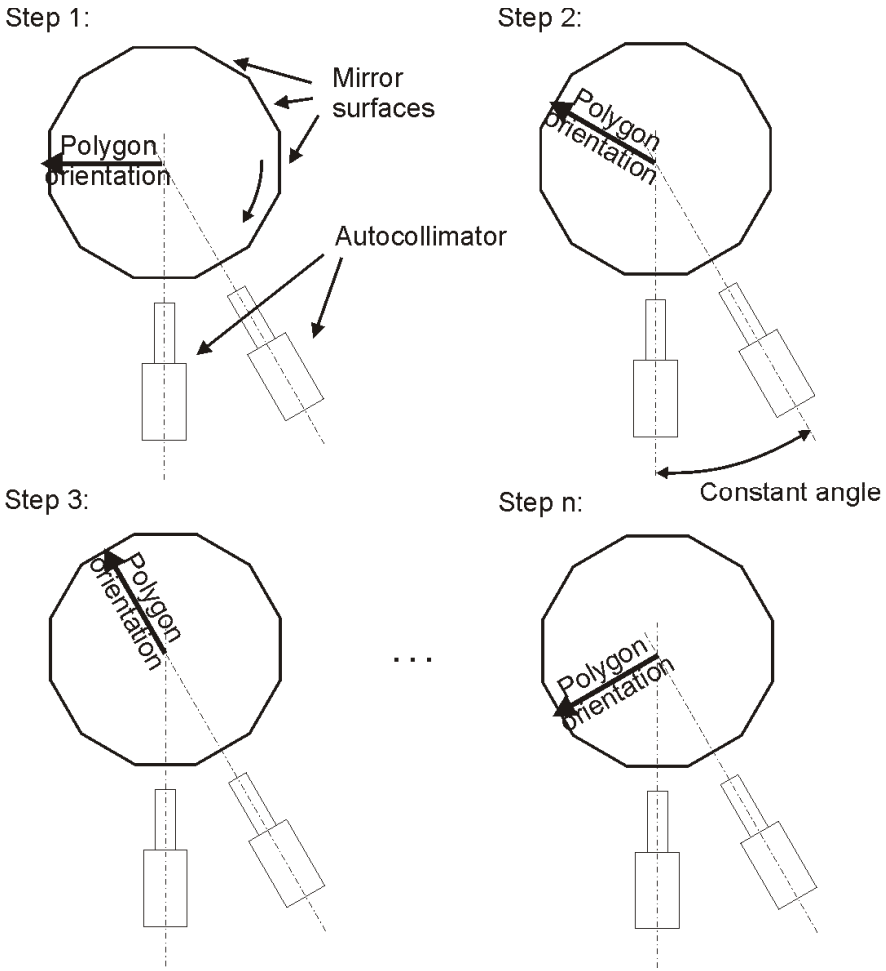
Horizontal Angle Tests

- *Air Bearing supported rotary table, Kugler GmbH, Salem, Germany*
- *Renishaw Signum RESM angle encoder system*
  - *4 read heads*
  - *0.01 arcsec resolution*
  - *1 as graduation accuracy*
  - *Measurement accuracy after calibration <0.2as*



Calibration of the rotary table (1)

- *Rosette technique*
  - *calibrate precision polygon prisms*
  - *sum of the angles measured must result in 360 degrees*
  - *Moeller-Wedel electronic autocollimator (0.1arcsec accuracy, 0.05arcsec reproducibility)*



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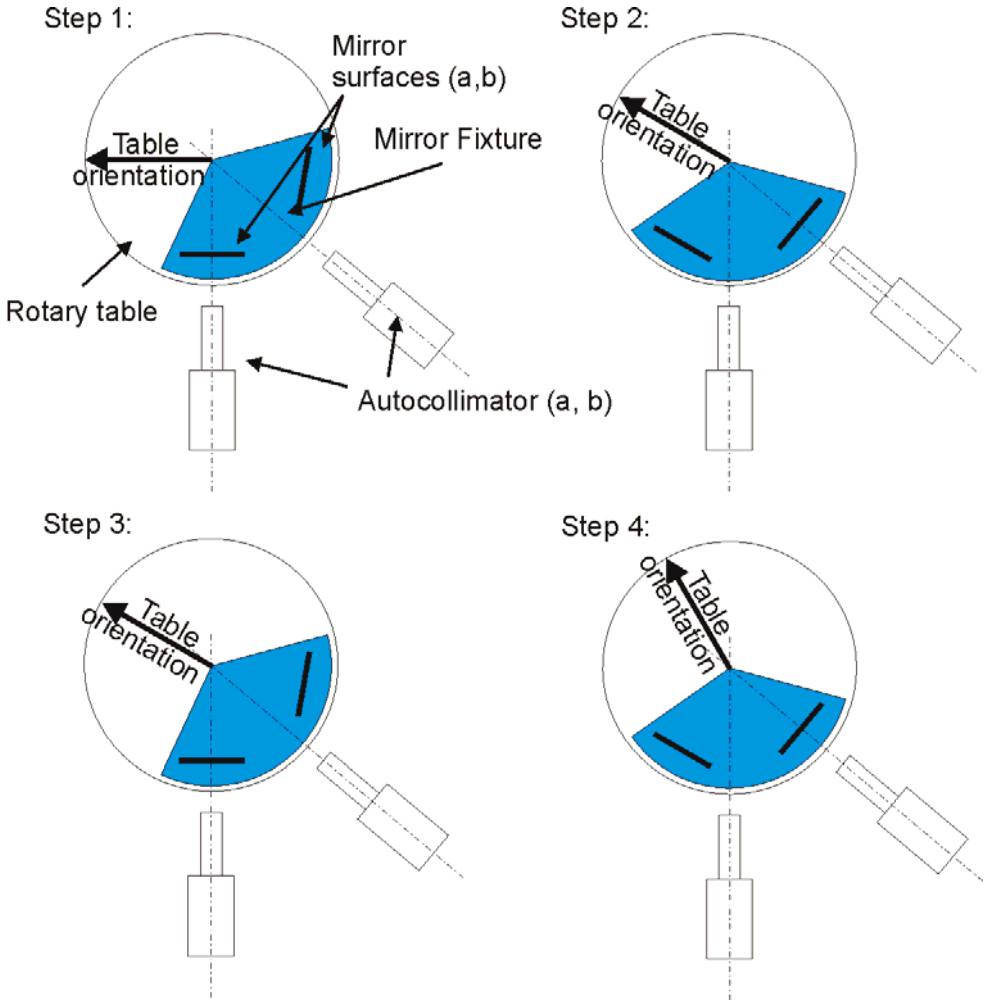
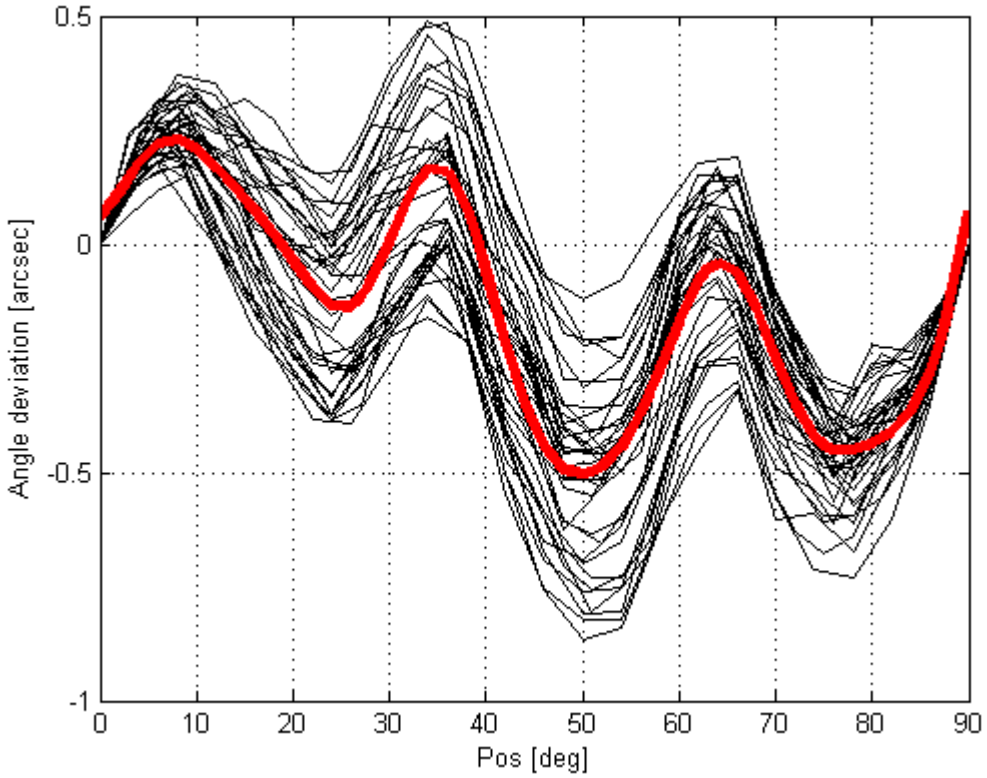
Calibration of the rotary table (2)

- *Derived Technique*
  - *set the fixture with the mirrors in a way that mirror 'a' is in line with autocollimator 'a'*
  - *rotate the table together with the fixture until mirror 'b' is in line with autocollimator 'b'*



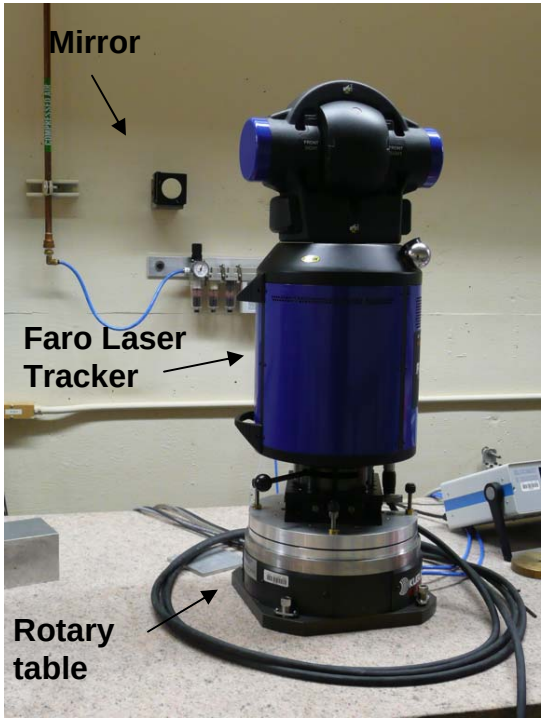
Calibration of the rotary table (3)

- *Absolute value of an angle between two positions of the rotary table can be determined with ±0.2 as StD.*



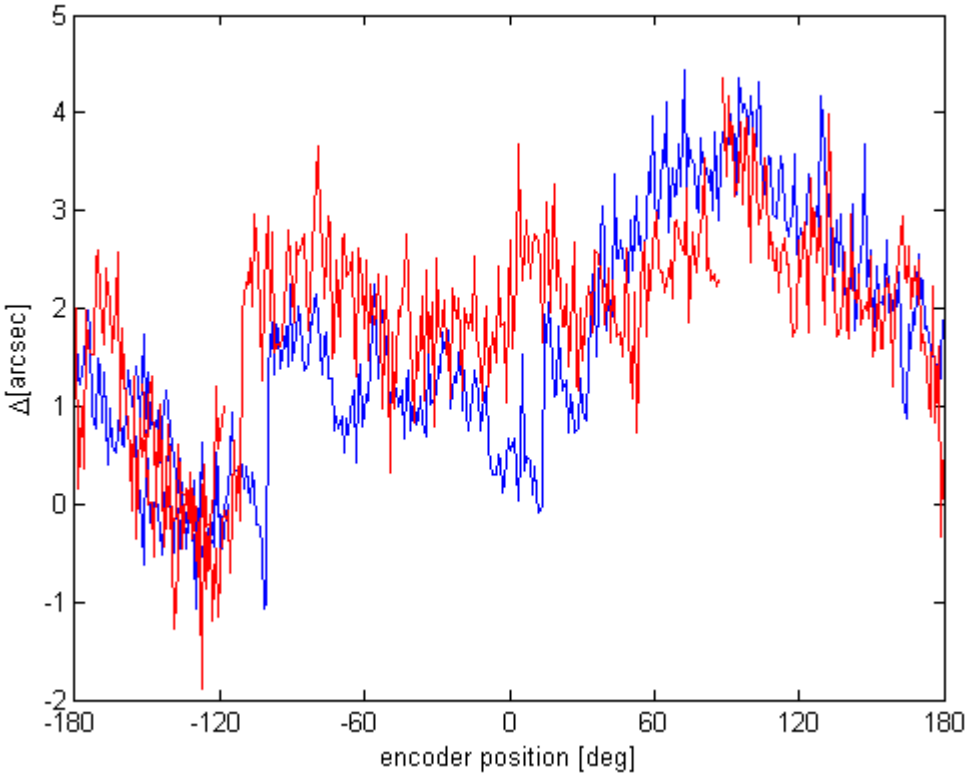
L T Horizontal Angle Test Set-up

- *Setup uses mirror as target for laser tracker pointing. Collimation avoids errors due to*
  - *non-parallelism of the two rotation axes*
  - *axial displacement of the rotation axes*



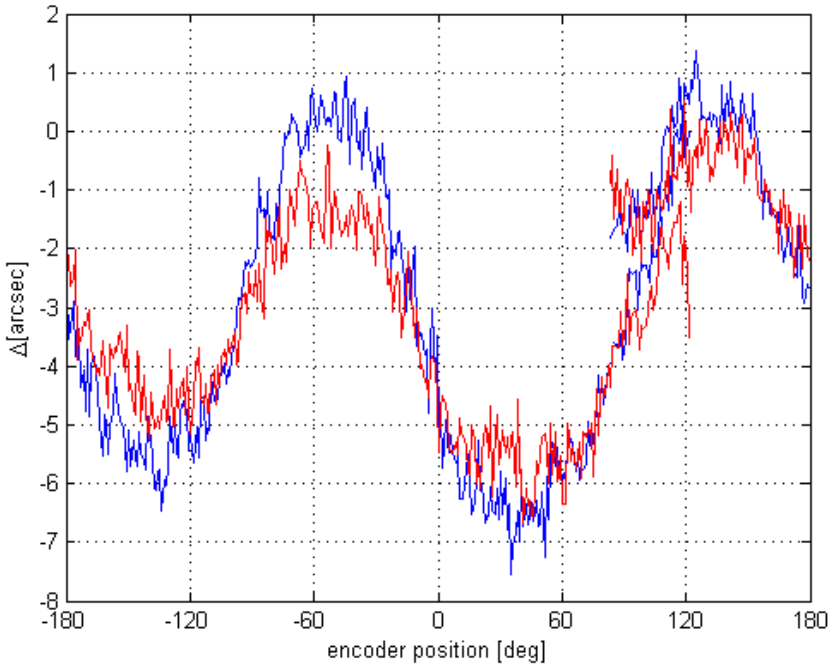
Comparison SMR vs. SMM

- *Test of Mirror (SMM) vs Retroreflector (SMR) pointing*
  - *Only small deviations can be found*
  - *Needs closer investigation in the 0 deg encoder region*

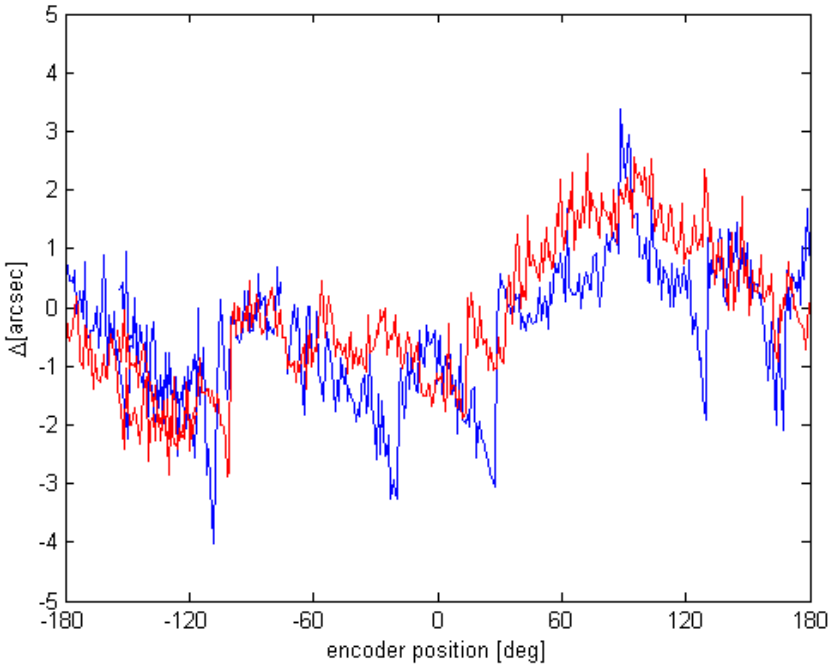


Preliminary Calibration Results

Two calibration runs with Tracker A



Two calibration runs with Tracker B



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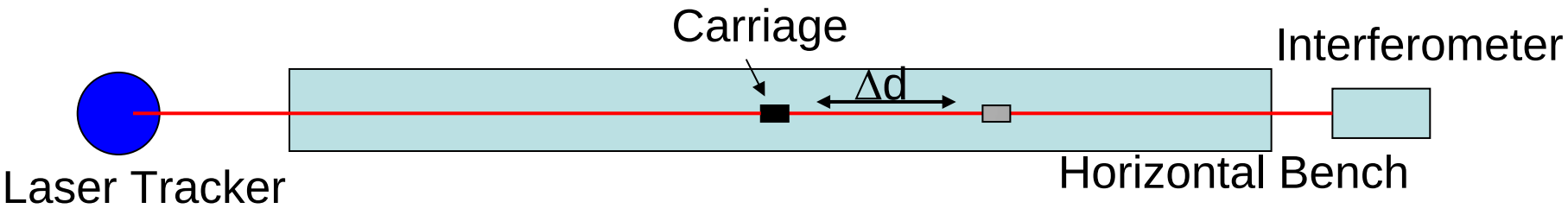
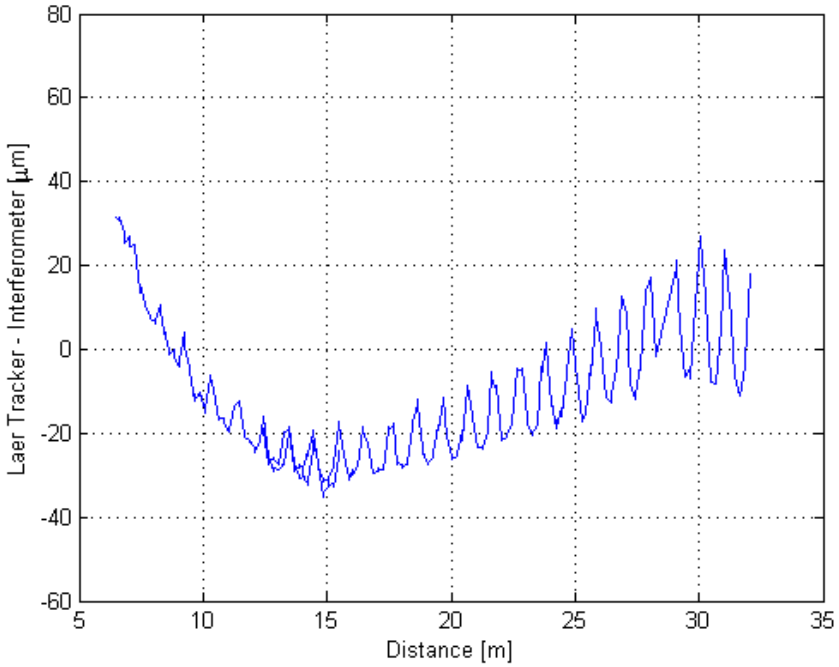
ADM Calibration on Interferometer Bench

- Test of ADM
  - Scale Factor
  - Cyclic errors
  - Tests of general performance and tests to detect malfunctions, e.g. count slips.

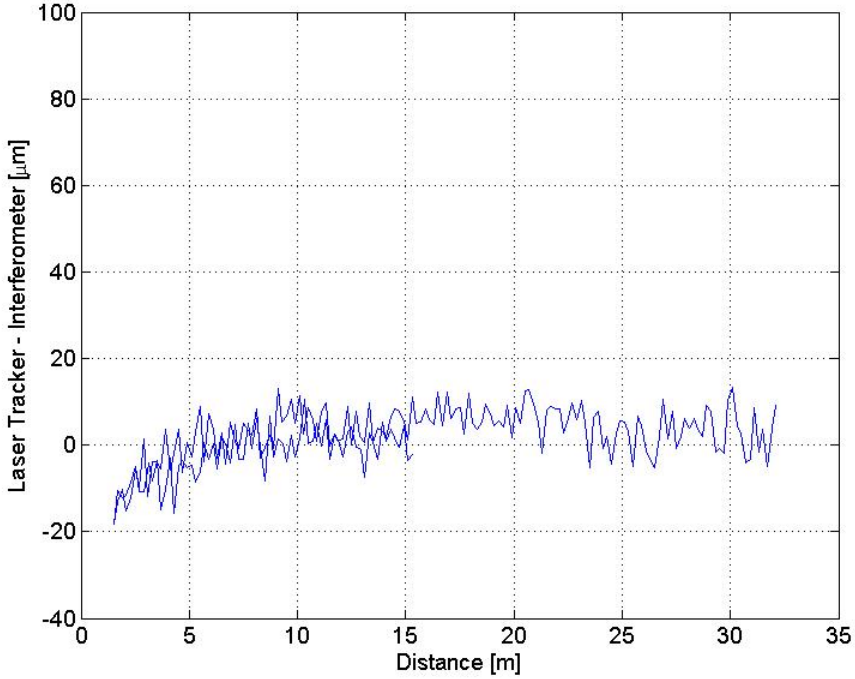


Calibration Results

Calibration run with Tracker A



Calibration runs with Tracker B



Conclusion

- We have established fully automated distance measurement test bench
- We are developing a test stand to calibrate LT horizontal angle measurements

- Future improvements:
  - Improve calibration accuracy
  - Certify system
  - Add vertical angle capability

End of Presentation