GLAST Network

Laser Tracker Study in SLAC
Building 33 - Room 104

Purpose

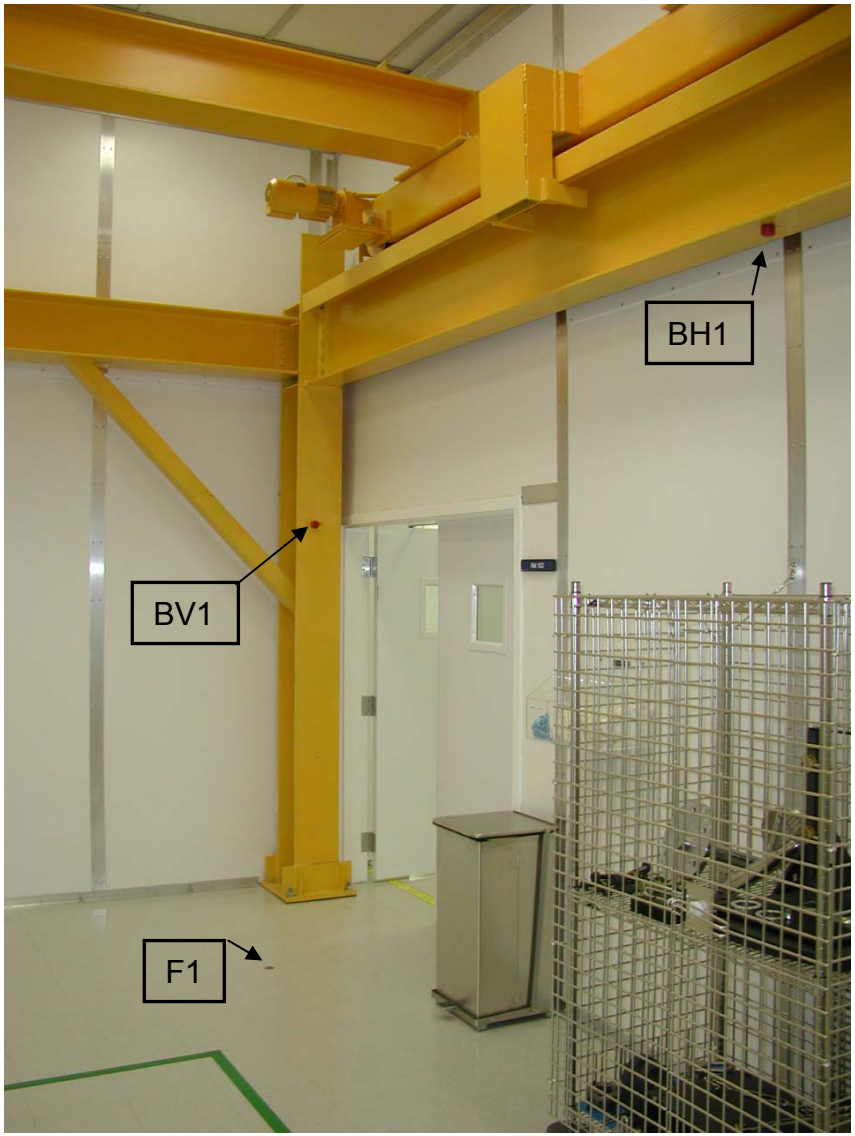
In February 2004, a first simulation was produced to qualify the TKR Optical Survey. It is based on a usual set of standard deviations for the laser tracker observations. To refine these choices, a real survey is proposed. The comparative analysis of the a-priori and a-posteriori standard deviations will determine the validity of the a-priori values for that particular room.

Network Description

- Existing Network:
  - 6 Floor Points
  - 10 on-crane Points
- Current Test:
  - 1 Test Point on Stand
  - 4 Laser Tracker Stations

Field Sequence

- 3/15/04 - 8:00 AM: Bring the laser tracker in Building 33.
- 3/15/04 - 11:00 AM: Clean all necessary gear (laser tracker, 2 stands, retro-reflectors…) in Room 102. Then bring the laser tracker in Room 103 and plug it in.
- 3/16/04 – 8:00 AM – 9:00 AM: Calibrate the laser tracker for both interferometric and ADM modes.
- 3/16/04 – 9:00 AM – 12:30 PM: Gather laser tracker observations.
- 3/16/04 – 3:00 PM: Start repeatability study.
- 3/17/04 – 11:00 AM: Stop repeatability study.
- 3/18/04 – 2:00 PM: Start repeatability study with a lower instrument stand.
- 3/19/04 – 2:00 PM: Stop repeatability study.



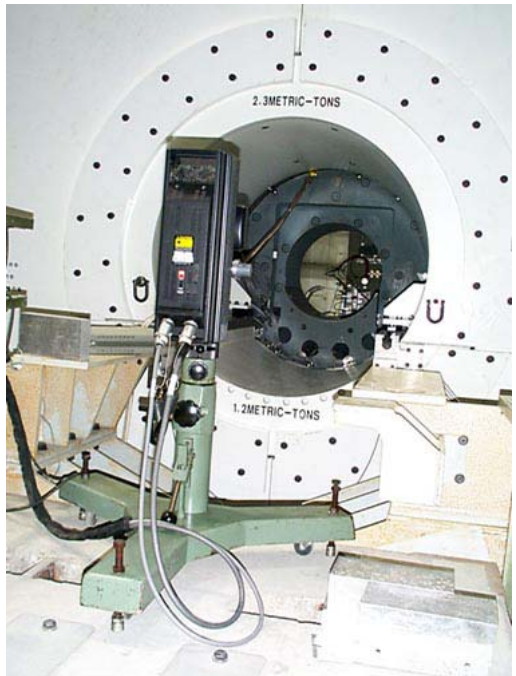
There are 3 sizes for commercial SMRs:

1.5” 0.875” 0.5”

The Alignment Engineering Group is currently carrying a stock of forty 1.5” and four 0.5”. The GLAST related surveys will be using the 1.5”.

For this particular test, 2 stations were observed with the stand in a high position as shown in the left picture, one station in medium and one in low.

The Alignment Engineering Group can use a different stand for very low set-ups (see archived picture below).



Field Procedure

- For all precise laser tracker surveys at SLAC, the following observation scheme is enforced:
  - 2 sets of observations per station.
  - 2 face measurements per set.
  - 2 minimum shots for each point.
- For this particular test, one of the issues to resolve was the use of interferometric mode versus ADM mode in the distance measurement. This lead to the modified observation scheme:
  - each station shoots each point 2 times in both faces: one in tracking mode and one in absolute.
  - each station observes all the points.

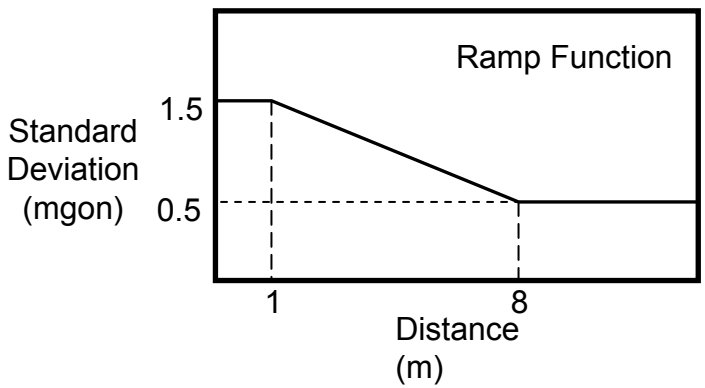
  In the processing stage, 3 solutions will be performed: pure interferometric, ADM and combined.

Network Statistics

- Primary Numbers:
  - Number of stations 4
  - Number of points 17
  - Number of observed triplets 67
- Derived Numbers:
  - Number of coordinate unknowns 63
  - Number of nuisance parameters 12
  - Number of datum parameters 6
  - Degree of freedom 132

First Adjustment Results part1

- A-Priori Standard deviations:
  - 30 μm for distances
  - The following ramp function for both angles:



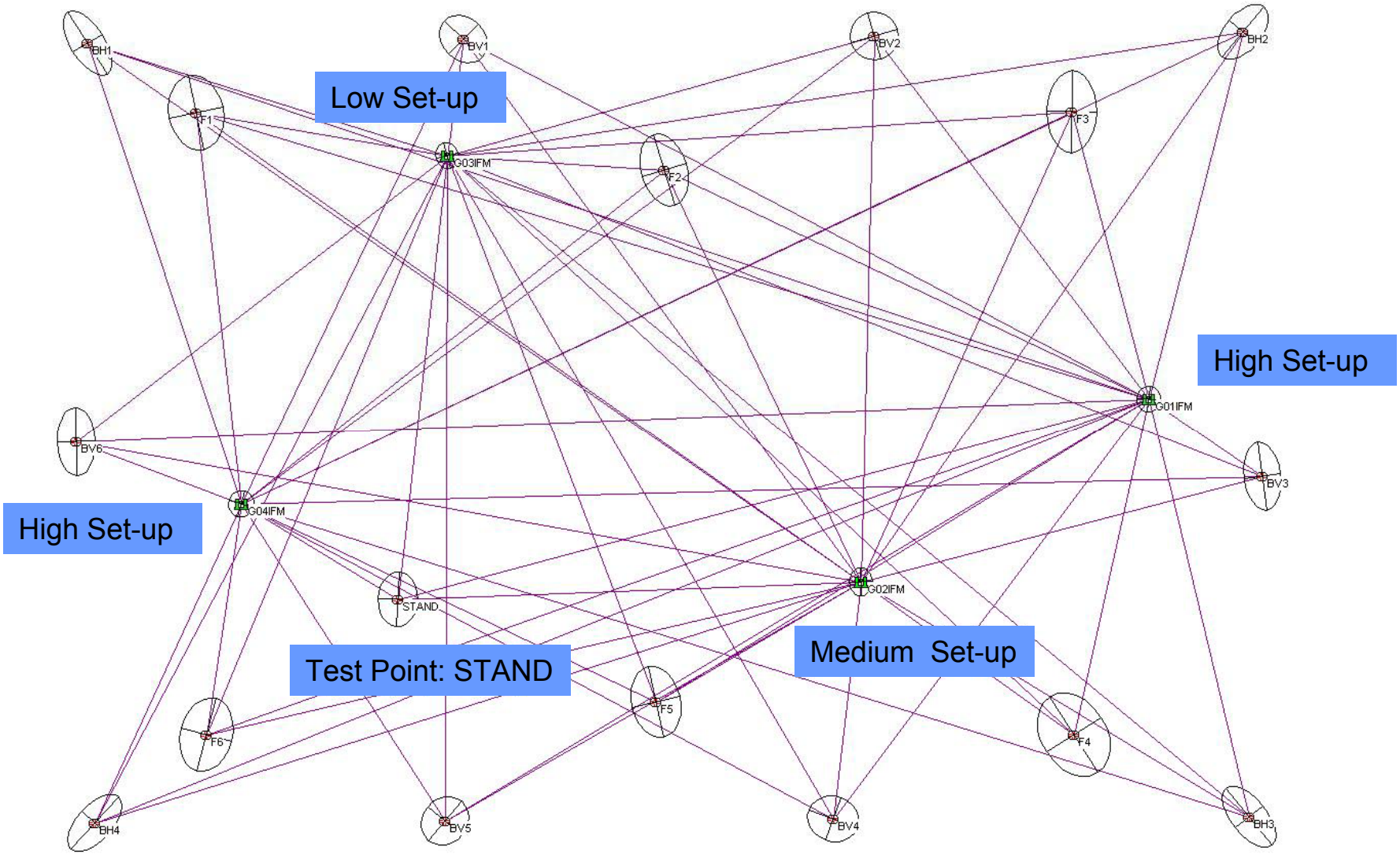
- Variance Analysis:

First Adjustment Results part 2

- ADM observations:
  - Distance sigma a posteriori 0.974385
  - Horizontal angle sigma a posteriori 0.627320
  - Vertical angle sigma a posteriori 0.397631
- Interferometric observations:
  - Distance sigma a posteriori 0.302170
  - Horizontal angle sigma a posteriori 0.428940
  - Vertical angle sigma a posteriori 0.236041

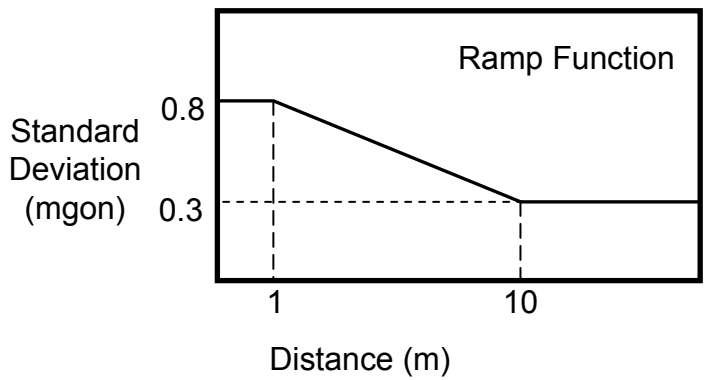
First Adjustment Results part3

- Both cases pass the one-tailed test on the estimated variance factor. Both failed the two-tailed test.
  - New values for a-priori standard deviations will be tested for distances. A new ramp function will be applied for both angles.
- All individual types of observations (distance, horizontal and vertical angles) residuals pass the Chi2 goodness of fit test.


Low Set-up
High Set-up
High Set-up
Test Point: STAND
Medium Set-up
BH1
BV1
BV2
BH2
F1
F3
G03IFM
F2
G01IFM
BV6
BV3
G04IFM
G02IFM
STAND
F5
F6
F4
BH4
BV5
BV4
BH3

Second Adjustment Choices

- A-Priori Standard deviations:
  - 8 μm for interferometric distances
  - 35 μm for ADM distances
  - The following ramp function for both angles:

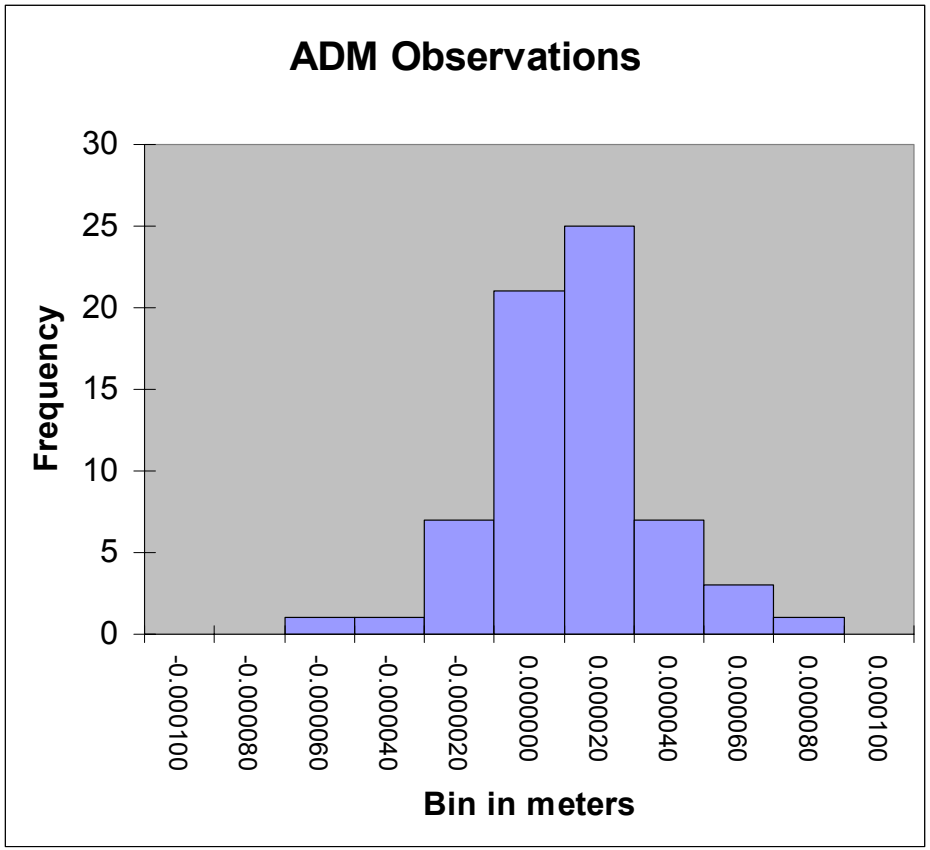


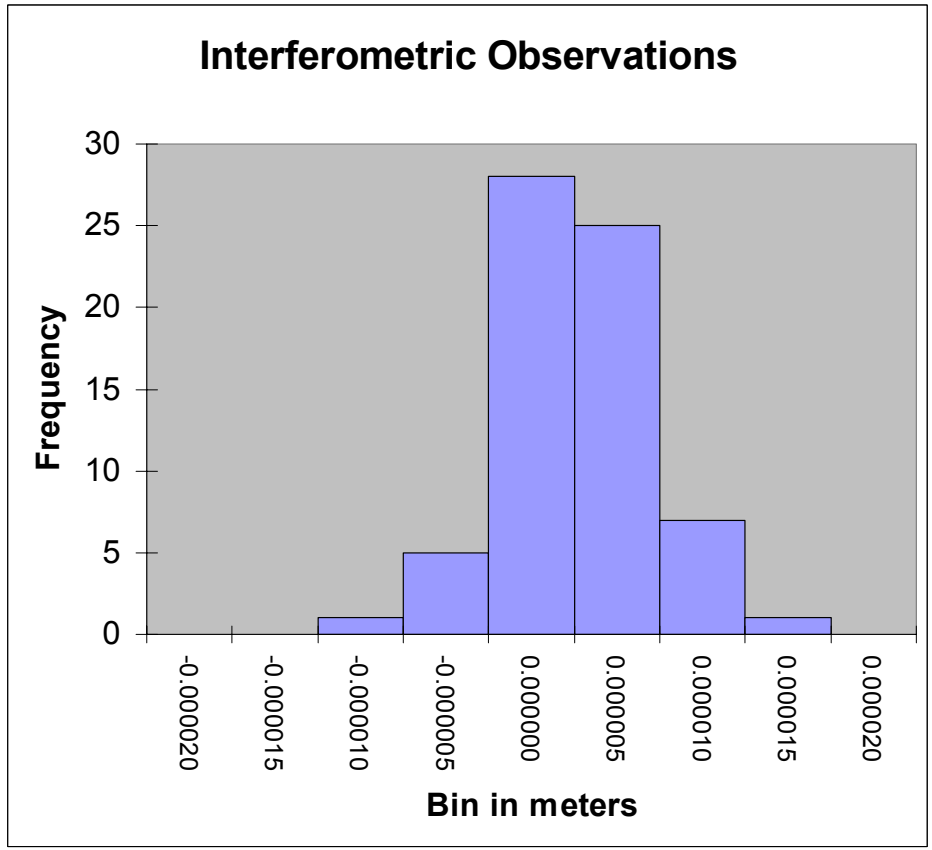
- Same set of approximate coordinates for all 16 permanent points.

Variance analysis

- ADM observations:
  - Distance sigma a posteriori 0.933783
  - Horizontal angle sigma a posteriori 0.843938
  - Vertical angle sigma a posteriori 0.515863
- Interferometric observations:
  - Distance sigma a posteriori 0.936582
  - Horizontal angle sigma a posteriori 0.722249
  - Vertical angle sigma a posteriori 0.436947

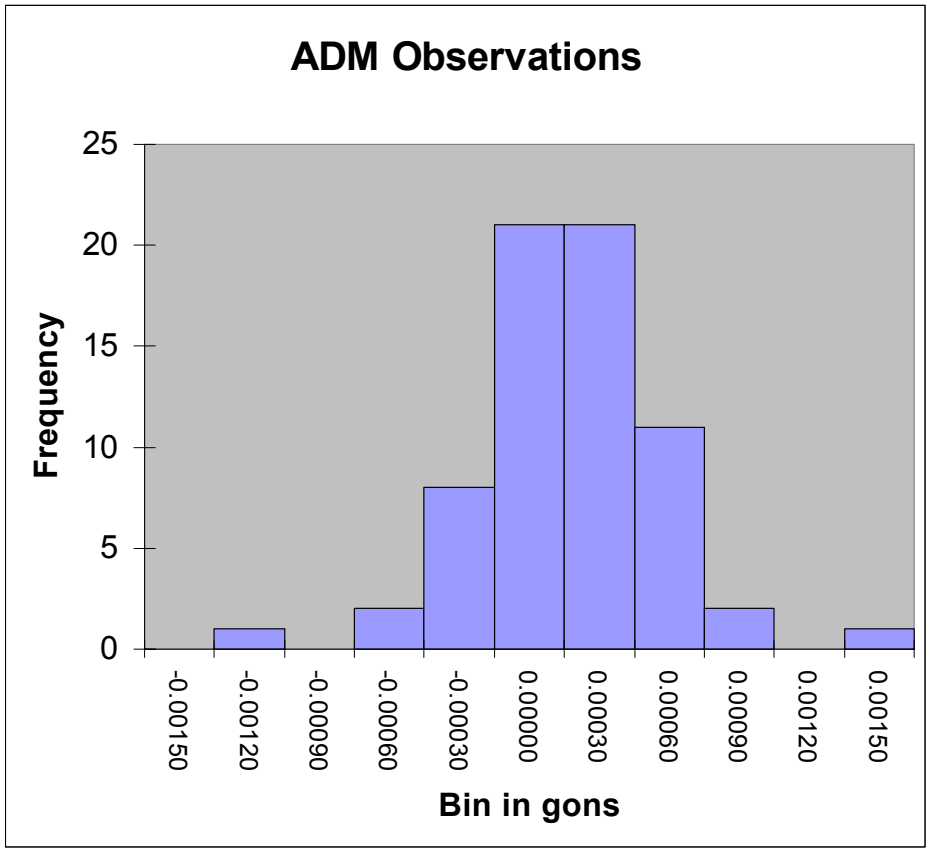
Distance Residuals Histogram

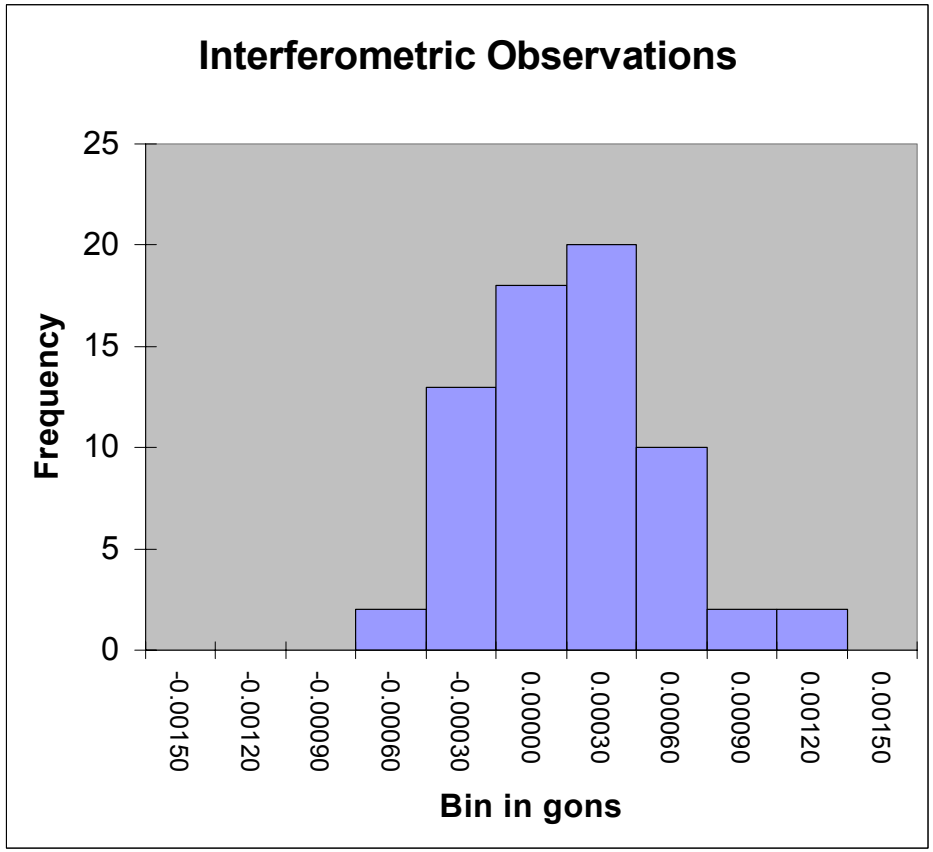




Note: Different bin range for ADM and Interferometric distance residuals

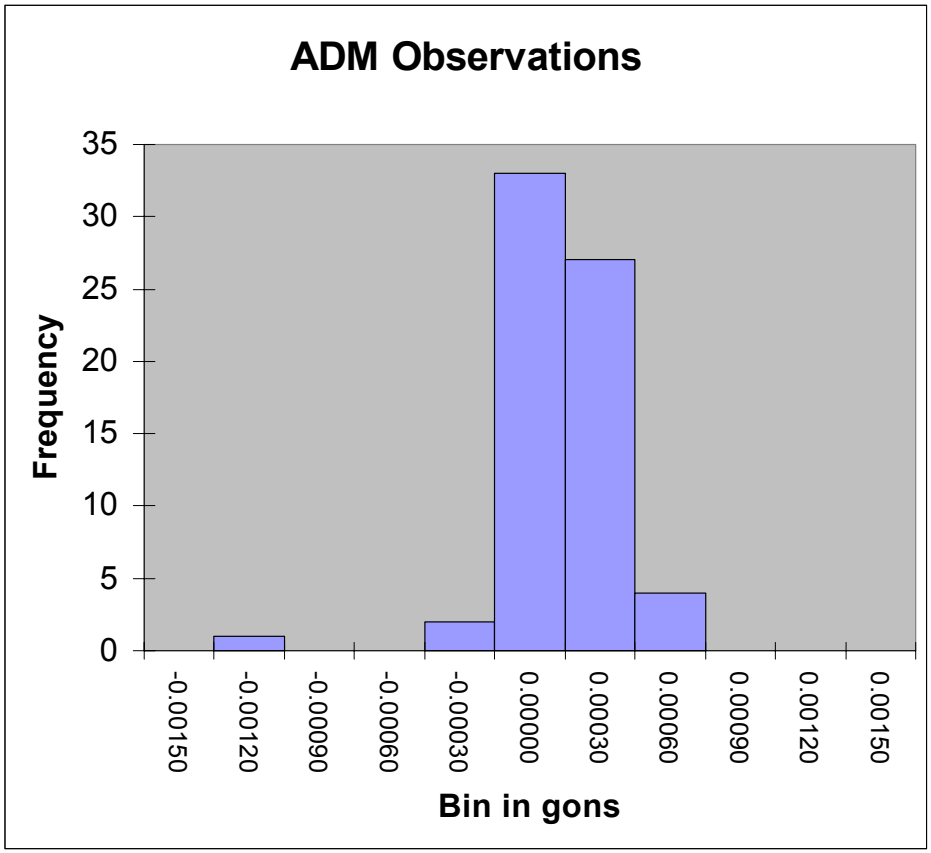
Horizontal Angle Residuals Histogram

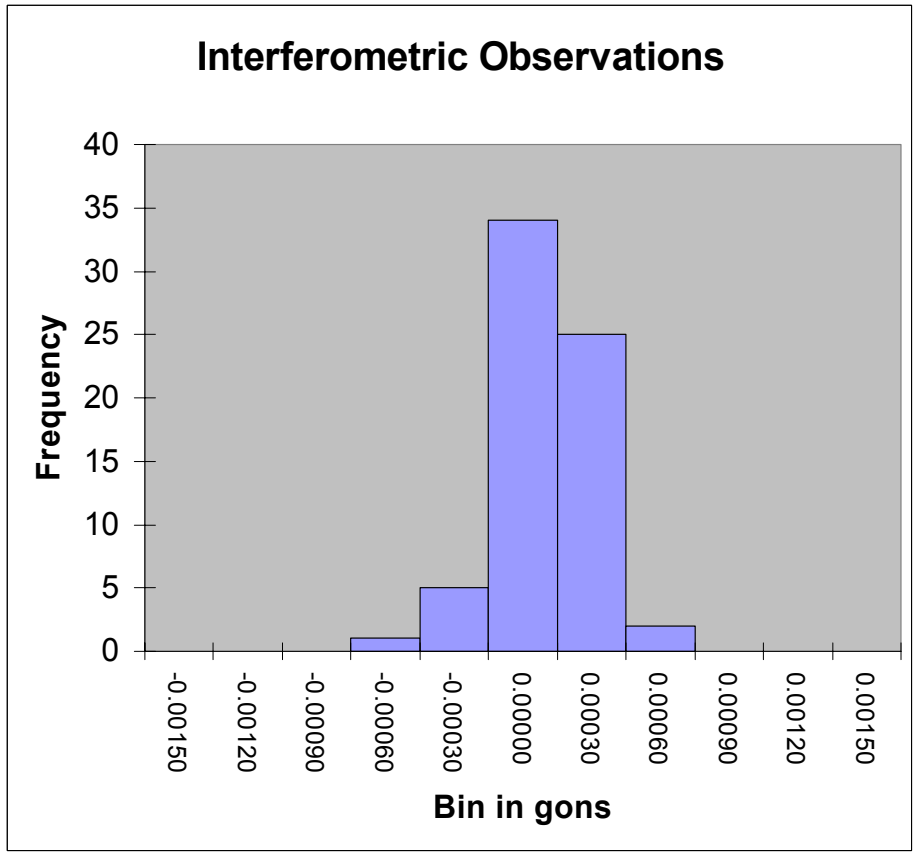




Note: Same bin range for ADM and Interferometric horizontal and vertical angle residuals

Vertical Angle Residuals Histogram





Note: Same bin range for ADM and Interferometric horizontal and vertical angle residuals

Test Point “STAND”

- ADM observations (reference variance 0.625741):
  - Standard Deviations on coordinates in meters

  0.000015 0.000015 0.000017
  - 2D standard ellipse (a & b in meter, orientation in degree)

  0.000016 0.000014 48.6
  - Predicted (not scaled a-posteriori) 99% confidence ellipse

  0.000063 0.000055 48.6
- Interferometric observations (reference variance 0.473370):
  - Standard Deviations on coordinates in meters

  0.000005 0.000006 0.000010
  - 2D standard ellipse (a & b in meter, orientation in degree)

  0.000006 0.000004 88.0
  - Predicted (not scaled a-posteriori) 99% confidence ellipse

  0.000027 0.000018 88.0
- Differences Interferometric and ADM free datum solutions:

  0.000017 -0.000012 0.000006

Conclusion

A better set of standard deviations suitable for the room was experimentally determined. The interferometric mode is definitively better but the ADM mode is faster and still very good. If the absolute measurement method is chosen, the a-priori standard deviation could most likely be lowered again to 30 μm as the field procedure will enforce two sets of observations and the test here had only one. The pending repeatability analysis will verify this statement.