

MEASURING 3D POINTS OPTICALLY THROUGH A TRANSPARENT PLEXIGLASS LAYER

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What we did

We used the CMM in Lab C to test how well we can measure 3D points optically through a layer of transparent material (plexiglass).

We used a certified reference granite surface that is flat to a fraction of a micron and measured a grid of one hundred 3D points on that surface. Then we fitted a 3D plane to those points and histogrammed the distance of each point to the best fit plane

We take the standard deviation of that histogram as our definition of the precision of the z measurement

We repeated the same measurement interposing a plexiglass sheet (5.5 mm thick) between the camera of the CMM and the granite surface and compared the results

The bottom line is that the z resolution changes from about $20\mu\text{m}$ (no plexiglass) to about $30\mu\text{m}$ (with plexiglass)

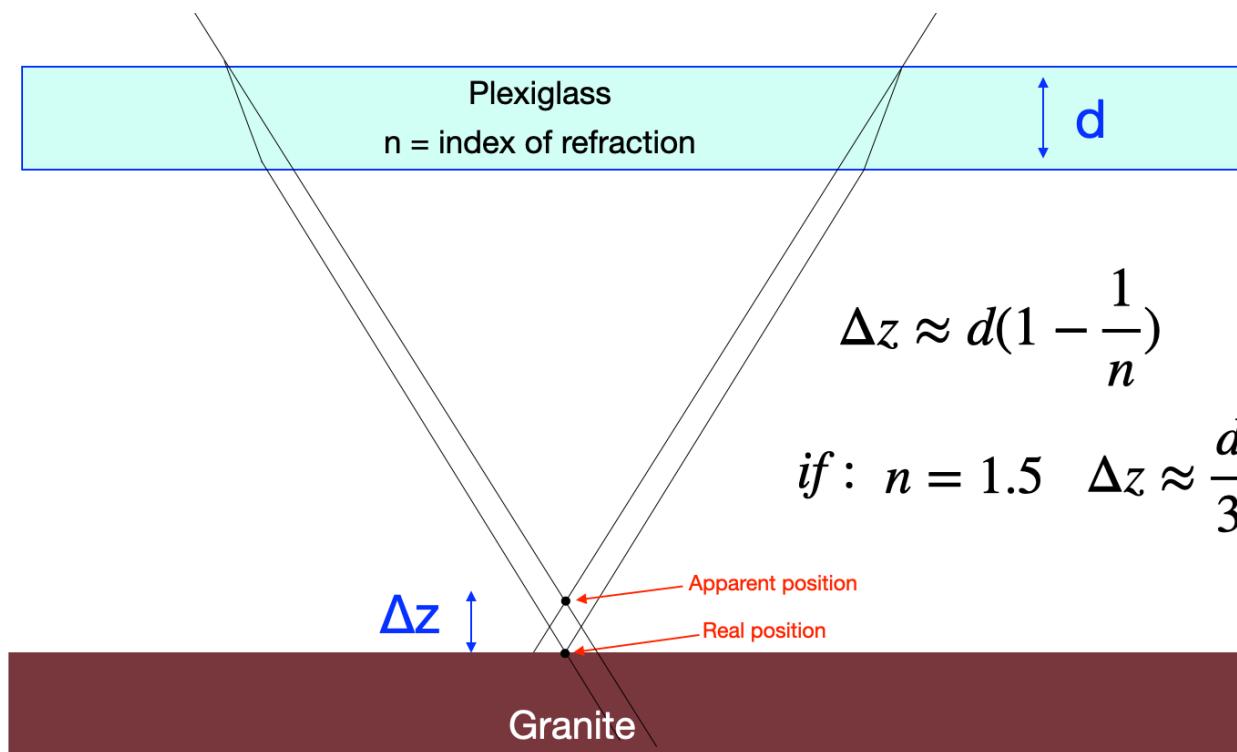
We assume that the degradation of the precision is due to the non-uniformity of the thickness of the transparent sheet

Effect of the transparent layer

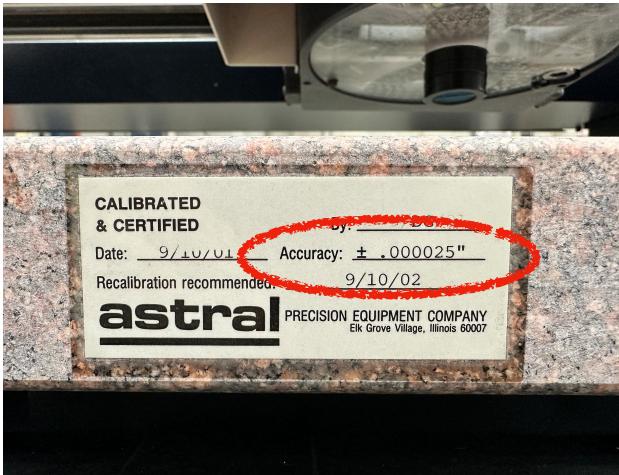
The interposition of a transparent layer between the camera and the object causes the apparent position of the object to move towards the camera by a distance that can be calculated from the thickness of the material and its index of refraction.

For $n = 1.5$, for example, the displacement is about 1/3 of the thickness

The displacement depends only on the thickness of the material and its index of refraction but not on the relative positions of the camera, the transparent layer and the object

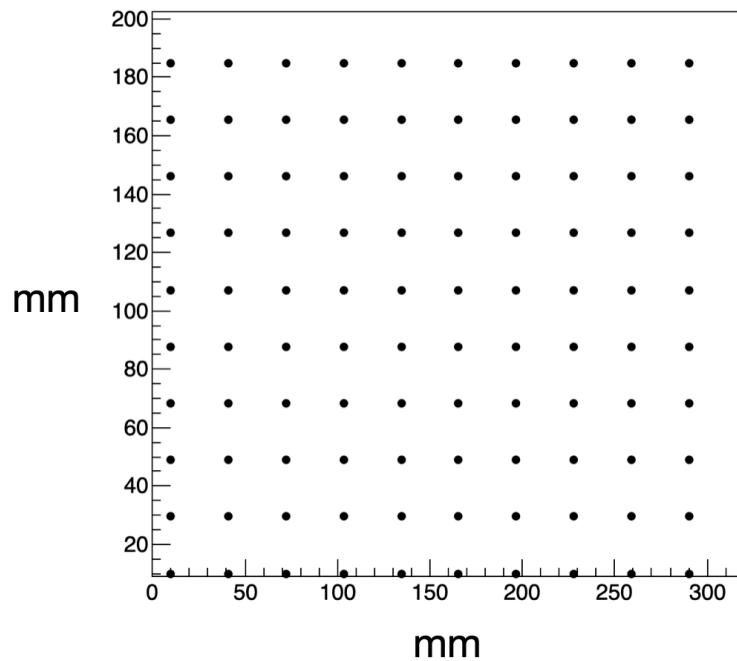


Certified reference surface (granite)



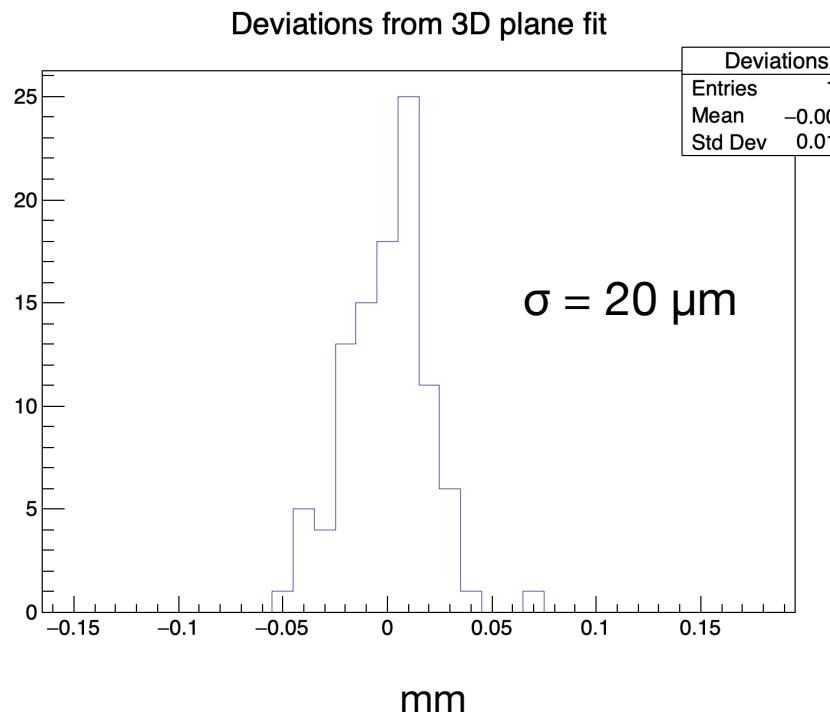
.000025" = 0.64 μm

10x10 grid of points

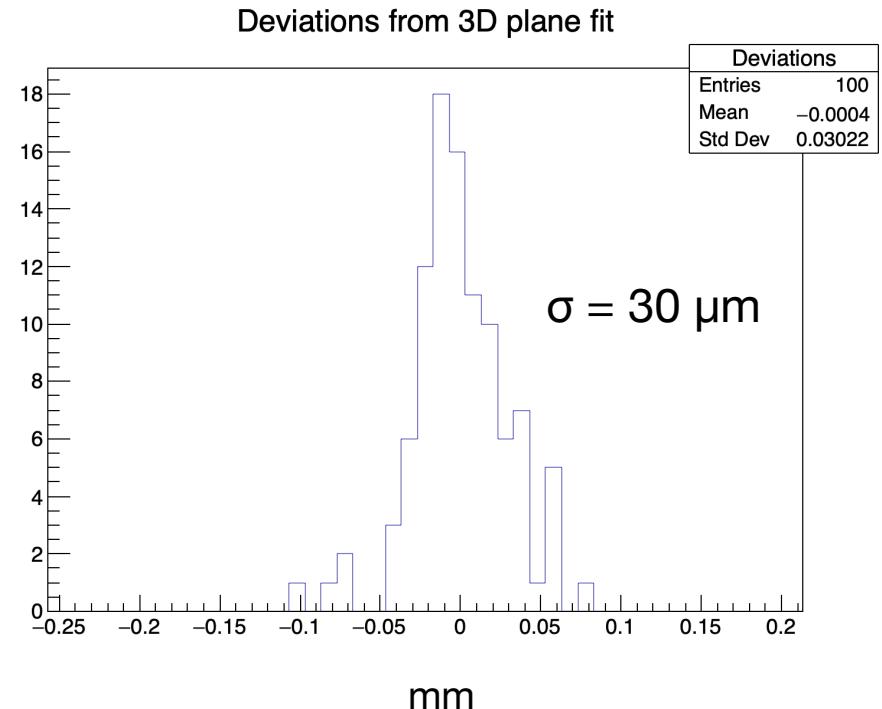


100 points

Without plexiglass



With plexiglass



$$\sqrt{(30^2 - 20^2)} \approx 22 \mu\text{m} \quad \text{contribution from plexiglass}$$

Assuming the index of refraction $n = 1.5$, this translates to a non uniformity of the thickness of the plexiglass of about $\sigma = 66 \mu\text{m}$

$$\frac{66 \mu\text{m}}{5.5 \text{ mm}} \approx 1.2 \times 10^{-5} \quad \text{Over a span of about 30cm}$$