Initial Gantry Survey

Version 1.00 - March 23, 2025

The assembly scripts have been written to minimize assumptions about site-specific geometry. The precision that is achievable is obtained by measuring small deviations from the nominal geometry, which is based on the design of the tooling. There are several measurements to be performed in sequence to measure these deviations:

1. Coordinates of the origin of the gantry coordinate system
2. Location of the HDI launchpad on the sets of 1x2 and 2x2 tooling
3. Height of the launchpad and assembly chuck surfaces
4. Gantry Head Camera Offset (GHCO) z-coordinate measurement
5. GHCO displacement measurement
6. Locations of pins on HDI launchpad and assembly chucks

Once these have been determined, the remaining corrections are derived from deviations in the placed locations of parts, compared with their expected positions. With these additional corrections, assembly precisions better than 5 um are achievable.

To begin this process, start by loading and running the 'Initial_Gantry_Survey' script.

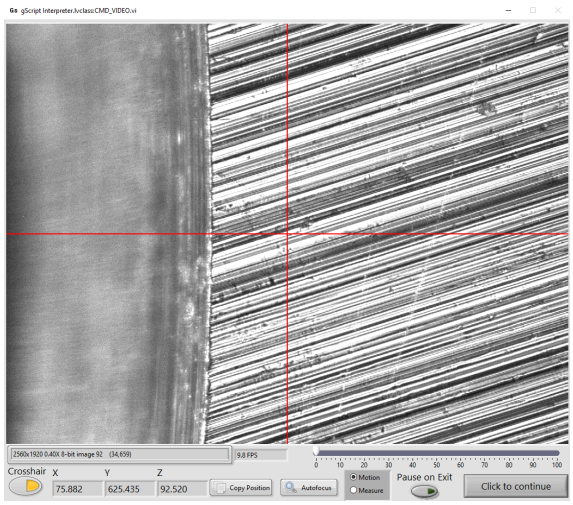
Gantry Origin

The origin of the gantry is defined in terms of the pattern of bolt holes. These are placed on a 6-inch grid and are used to mount the TFPX module assembly tooling. If we know the location of one bolt hole used to mount the tooling, then the nominal coordinates of the tooling components are then determined.

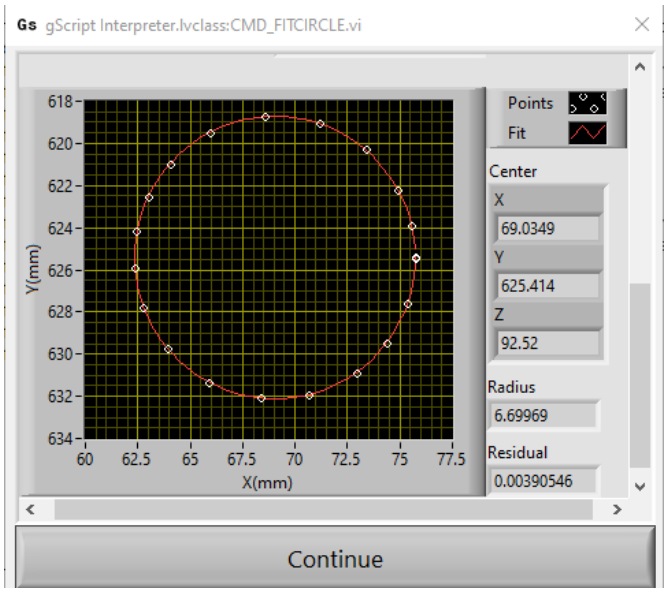
The first prompt from the script asks for the indices of one of the mounting holes on the assembly tooling. Holes are numbered i=0,1,2,... starting from the left in x, and j=0,1,2,... from front to back in y. For example, the 1x2 assembly tooling at Purdue has the front-left mounting hole at bolt hole index i=1, j=0. So we enter '1' for the X-index prompt and '0' for the Y-index prompt. The gantry will then move to where it expects to find this bolt hole based on the initial bolt hole origin set in the script. If this is the correct hole, then you can proceed. If it is way off, then you need to stop and consider why that might be. Did you count the holes incorrectly?

If you can confirm that it correctly found the front-left mounting hole of the selected set of tooling, then you can proceed to measure precisely the position of this hole and the height of the ¼-inch plate that the tooling is mounted on. When ready to survey this hole, press 'Yes, continue'. This step can be time consuming because the circumference of the chamfer on this hole is large. If it has already been performed and the coordinates are stored in the flex-config file (or the script directly), then it can be skipped.

When first surveying the bolt hole, we do not assume that the height of the gantry camera has been calibrated. Thus, it moves to a “safe” distance of z=50 mm and it is necessary to bring the camera into focus by adjusting the height using the A3200 Motion Composer. At Purdue, the tooling plate is in focus when z=92.5 mm but this might be different for other assembly sites. Also, be aware that the camera will initially be looking at the middle of the mounting bolt, and the gantry camera will have to be moved to the left or right by several millimeters to find the surface of the tooling plate.



Next, select points on the outer circumference of the chamfered surface. The circumference is large, so selecting points spaced by about 1 mm should be plenty. Click to continue, to register a point, and then continue to select more points. Once a sufficient number have been collected, then you can fit the circle. A reasonable fit typically has a residual of about 5 um, as is seen in this example:

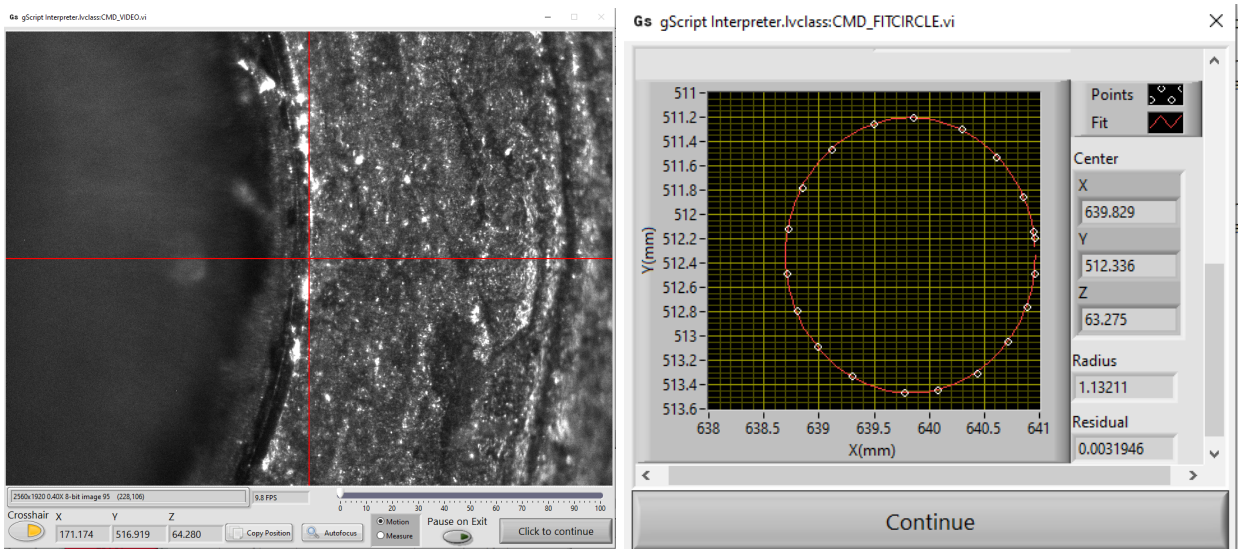


If the fit is unsatisfactory, then you can repeat this process. If it was satisfactory, then the new bolt-hole origin is now known and you can update the flex-config file or other scripts that need it.

Launch Pad Location

Once the positions of all bolt-holes can be accurately calculated, we will know the nominal positions of the tooling for 1x2 and 2x2 module assembly. To determine their precise locations, we start by measuring the position of the top (round) pin on the HDI launchpad for the 1x2 tooling. You can skip this step to move on to surveying the 2x2 tooling.

First, specify the positon of the front-left mounting hole of the 1x2 tooling. These are generally the same indices used for the gantry origin measurement, so at Purdue we enter ‘1’ for the x-index and ‘0’ for the y-index. The camera will then move to the nominal position of the top pin. If the nominal position is accurate enough, the camera will be looking into the dark hole in the middle of the pin. From here, you need to move the camera so that it focuses on the flat top surface of the pin and survey the circumference of the hole in the middle. The top surface is found by noting that it is all in focus simultaneously, whereas the angled surfaces will only have a small field of view in focus at one time. The lighting can also affect how well the circumference can be viewed. With light shining from the left, this is what the top surface looks like:



Select points on the circumference, and fit the circle. If the fit is satisfactory, then the position of the top pin is determined precisely and the script proceeds to ask if you want to update the flex-config file (or otherwise record the new top pin location). After this step, the script prompts for the indices of the front-left mounting hole for the 2x2 tooling and proceeds to survey the location of the top pin on the 2x2 HDI launch pad. At Purdue, the 2x2 tooling is mounted at bolt hole location (4,0).

Height of Tooling

The nominal height of all tooling surfaces are known since the height of the tooling plate has been measured. The chucks are made from precision aluminum that is ¾ inch thick, and the assembly module carriers are ¼ inch thick, so we know that the launchpad and assembly carrier surfaces are 19.05 and 25.40 mm above the tooling plate, respectively. The script moves the camera to the nominal center of each chuck and waits for you to focus on that surface. Note however, that there is a vacuum pocket at the center of the HDI launch pad, so the camera needs to be moved by a few millimeters to be looking at the actual surface of interest. Often, the nominal height estimate is quite accurate and there will be no need for major adjustments to achieve a good focus.

This step is then repeated for the chip launch pad, and the five assembly chucks. Make sure to place an assembly module carrier on each assembly chuck before measuring the height. Once the 1x2 tooling has been measured, the script proceeds to measure the height of the surfaces on the 2x2 tooling. When this has been completed, the script prompts to write these new measurements to the flex-config file, or propagated into the subsequent scripts.