Updates from the Lab: Some Testing with MHTestB

Some Preliminary Observations & Measurements

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SLAC MAGIS Group Meeting

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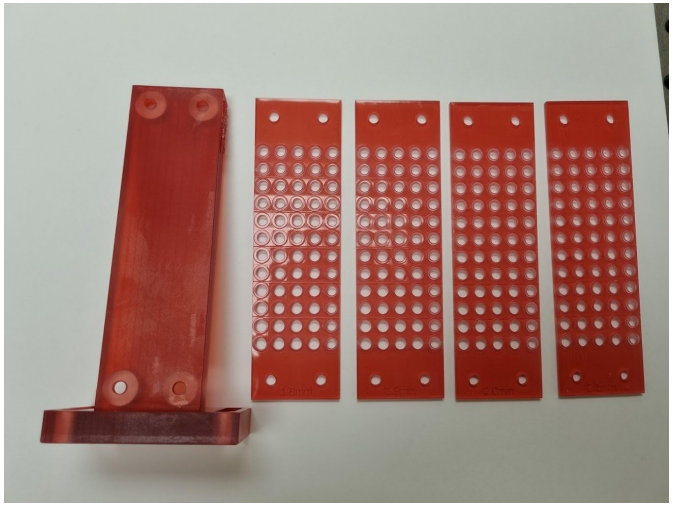
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

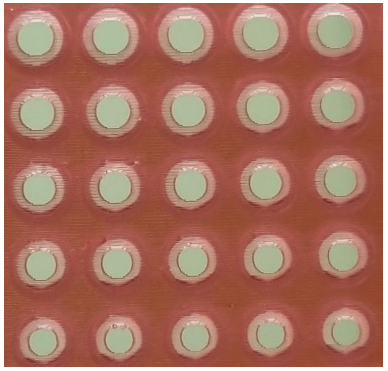
More Deliveries at the Lab

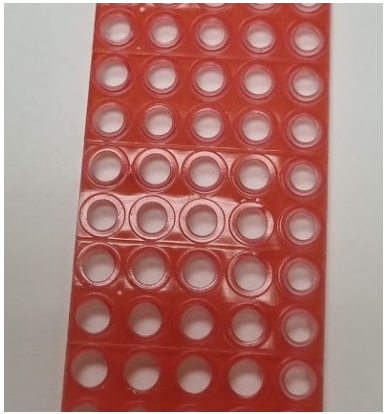
- MHTestB
  - 1 “local support” board
    - 1cm thick
  - 4 “front” boards
    - Thickness: {1.8, 1.9, 2.0, 2.1} mm
  - Boards screwed together by #8-32 screws
- Rubber sheets
  - Padding between the two boards
  - Thickness: {1/64”, 1/32”, 1/16”} corresponding to {0.4mm, 0.8mm, 1.6mm}



MHTestB: Printing Direction

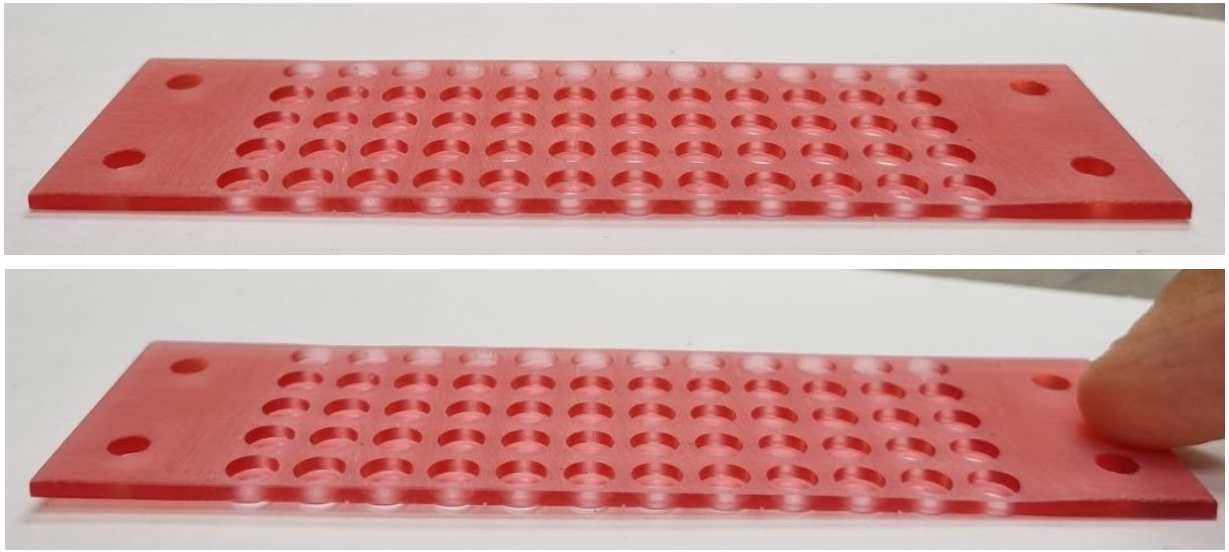
- Local supports are printed vertically
- Front boards are printed horizontally
  - Huge difference in overall smoothness & hole inner diameter
  - 5.3mm and 5.4mm both feel very loose
- This was done at the company's discretion; perhaps worth specifying printing direction next time
- What do we expect from the final "dome" shape? How would the diagonally printed holes look like?





MHTestB: Flex in Front Boards

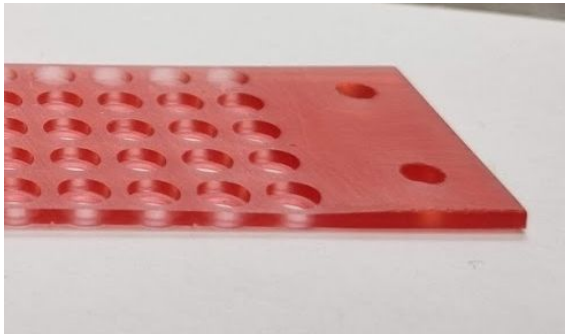
- Front boards are convex to the front side
  - Similar behavior all across the 4 boards
- Makes it difficult for the mirrors in the central region to be pushed properly



MHTestB: Non-uniformity in Front Boards

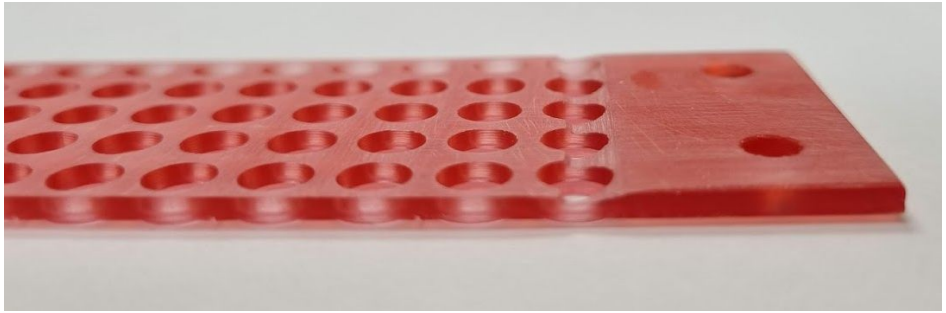
- Front boards have non-uniform thicknesses
  - Was designed to be uniform at {1.8, 1.9, 2.0, 2.1} mm
  - 0.3mm - 0.4mm thicker in the bottom & top regions (visible amount!)
- Digital caliper measurements

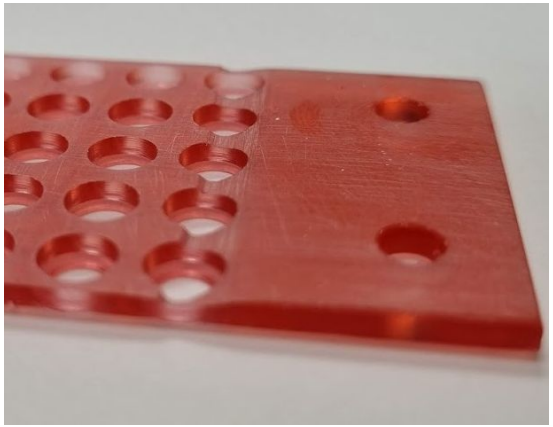
Board Type	Thickness [mm] @ bottom region	Thickness [mm] @ center region	Thickness [mm] @ top region
1.8mm	2.24	1.86	2.13
1.9mm	2.33	1.91	2.31
2.0mm	2.44	2.03	2.40
2.1mm	2.37	2.06	2.44



MHTestB: Damage on 1.9mm Board

- The very bottom row of 1.9mm front board has significant damage
- What caused it?
  - Printing process…?
    - Unlikely, considering the printing direction
  - Handling process @ company
  - Delivery





Summary on 3D Print

- Horizontally printing the holes seems like a good idea
  - Smoother surface
  - More precise control of actual inner hole diameter
  - But how would the “diagonal” holes in our dome look like?
- Overall, worse-than-ideal print quality this round
  - Flex & thickness variation really hurt our tests
  - Where do these come from?
    - Printing/curing process? Specific to certain material?
    - Does this only happen to thin boards? Or regions with much empty area like our grid of holes?
  - Resolve these issues before setting precise design parameters
- Any other options…? Less-than-$1M machining for our prototypes?

Some Tests, Nonetheless

θ = Mirror alignment (w.r.t. laser)

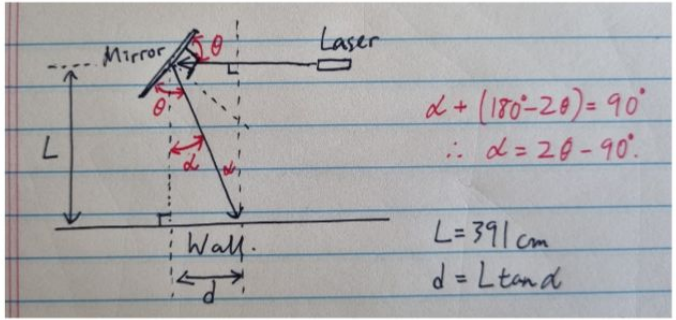
α = Angular position of the beamspot @ wall

L = Distance between optics & wall

d = Linear position of the beamspot @ wall

$$\Delta\theta = 0.1^\circ \implies \Delta d = 13.66\,\text{mm}$$

We want all our beamspots within ~10cm!

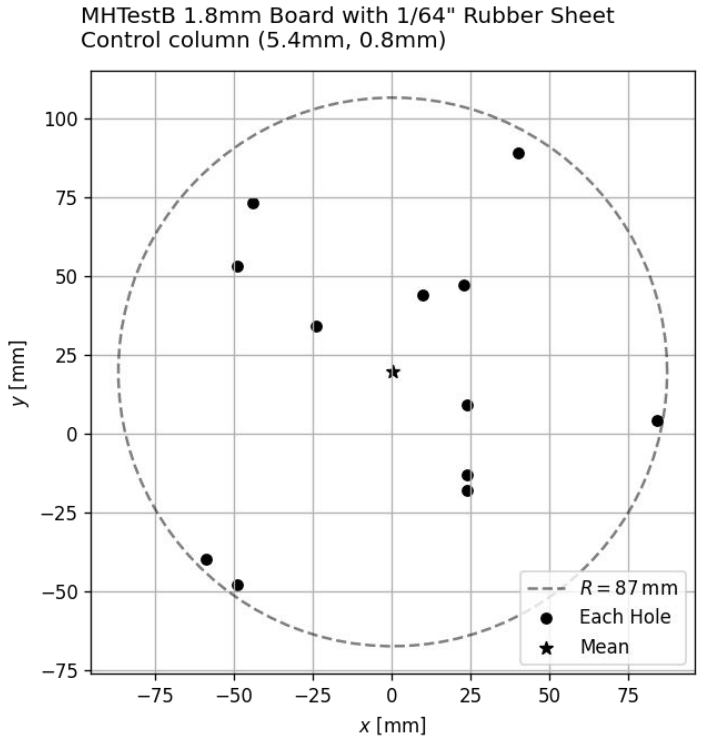


Main results from some preliminary tests

- Verification of design (push-in mechanism)
  - Effect of rubber padding
- Effect of front-stop overlap radius

Measurement 1: First Verification of the Design

- 1.8mm front board, “control” column
  - 12 identical holes
  - 5.4mm diameter, 0.8mm overlap radius
  - Repeated across different front boards
- Full result with 1/64” rubber sheet
  - All beamspots **within 87mm radius** from mean, corresponding to **±0.64deg**
  - No obvious trend within the column
- Quick test (no data recorded)
  - A similar (perhaps slightly worse) result was observed with the same 1.8mm board without rubber sheet
  - No visible damage to mirrors



Issues with the Front Board Thicknesses…

Then, we wanted to try the 2.1mm board

- Noticed **significantly larger span** with and without rubber
  - ~120mm radius, ~0.88deg
- Then, upon closer visual inspection, it was noticed that **the mirrors were not properly pushed in by the local support**
  - Bottom/top are significantly thicker than the mirrors
  - The front board is bent
  - Too much pressure from the screws can further bend the board

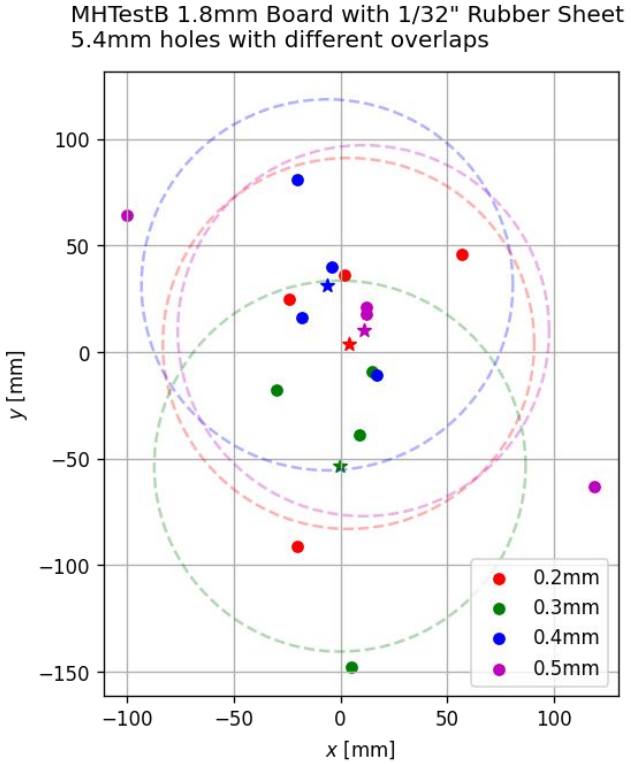
Wait… Re-visiting the 1.8mm Board

- 1.8mm board edges also slightly thicker (2.24mm, 2.13mm)
- Along with bending effect, our mirrors could again be floating
- Was this happening in the no-mirror run?

- Yes, indeed!
  - But there is very little room, maybe 0.1mm
  - That corresponds to ~1.15deg
  - Not terrible, but not good enough ⇒ 2.13mm, 2.24mm edges are no good

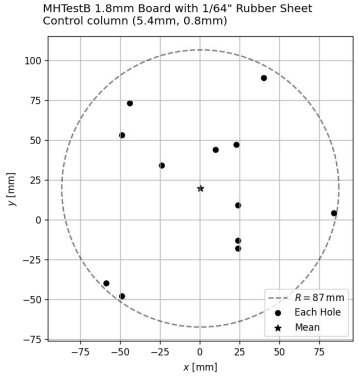
Measurement 2: Scanning Front-stop Overlap

- 1.8mm front board + 1/32” rubber sheet
  - 5.4mm diameter holes
  - Front-stop overlap: {0.2, 0.3, 0.4, 0.5} mm
  - 4 holes per parameter
- Overall, quite a bit worse than 87mm
  - More like 130mm, 0.95deg
  - Possibly due to bending of front board
    - Need to fine-tune screw strength
- No noticeable trend
  - Larger overlaps no more stable than smaller ones
  - This is worth decreasing, if possible



Lessons from Tests

- Caveats
  - Our boards are not what we wanted/expected
  - In particular, the bend & the thickness variance
- **First successful demonstration** of push-in mounting
  - Within ±0.64deg span
  - Sensitivity to screw strength makes this hard to reproduce consistently
- It seems like the front-stop **overlap doesn't have to be very thick**
  - We should test lower values again next time (0.2mm to 0.5mm)
- Hard to test further before we get **more precise prints**



Discussions points

- What is causing such big problems in the 3D prints?
  - One time bad luck? Material? Thin, perforated design?
- Shall we contact the company? Re-print? Re-print with other companies?
- Do we have other options? Medium- or low-quality machining?

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