

Mechanical Testing of Mirror Holder MHTestAn

Overview & Preliminary Results from June 9th

Sanha Cheong

SLAC MAGIS Group Meeting

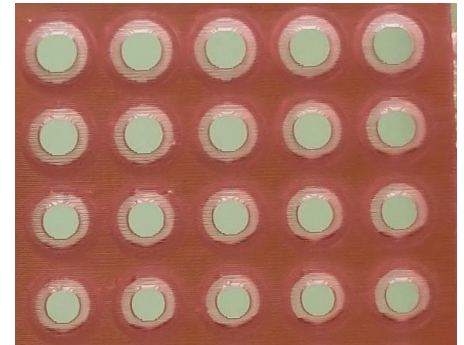
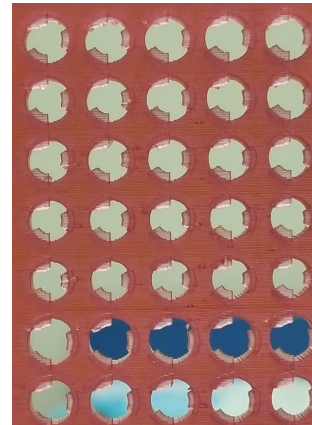
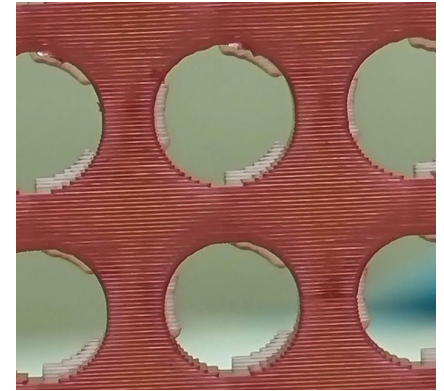
Jun. 10th, 2021



3D Printed MHTestAn Boards

Visual Inspection

- Holes
 - Can see the finite granularities
 - The holes are not actually “circular”
 - This makes **the innermost dimensions smaller**
 - Smallest feature is $\sim 100\mu\text{m}$
- Front-stops
 - Full ring ($n=1$) seems smooth
 - Other smaller legs have issues
 - Potentially due to printing directions



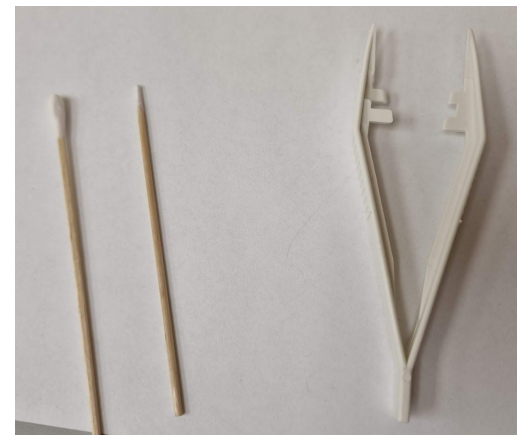
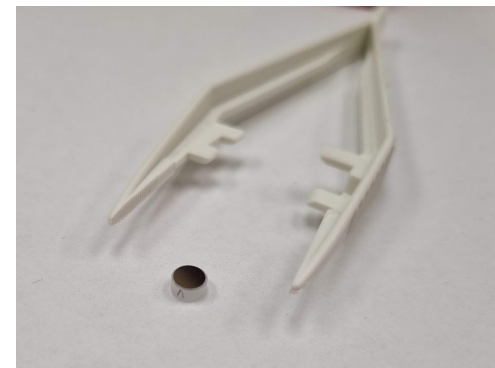
Handling & Inserting the Mirrors

Handling tools

- Two q-tips
 - Large: ~5mm or larger
 - small: ~1mm @ tip
- Plastic tweezer

Experience from inserting a few so far

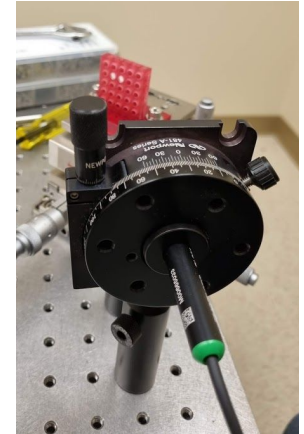
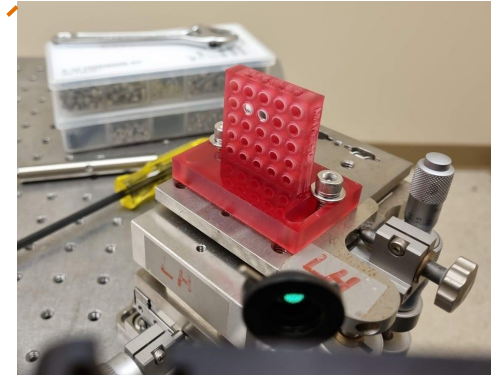
- Hole diameters: {4.6, 4.8, 5.0, 5.2, 5.4} mm
- 5.0mm or smaller: do NOT fit
- 5.2mm: quite tight to push in, but stable at
 - Some mirrors + holes won't fit together
- 5.4mm: slides in smoothly without friction



Lab Settings

520nm USB Laser

- Beamspace reduced with an iris
- Mirrors at 45deg
- Beam reflection across the room
 - 154", 391.16m
 -



Sensitivity to Angular Alignment

θ = Mirror alignment (w.r.t. laser)

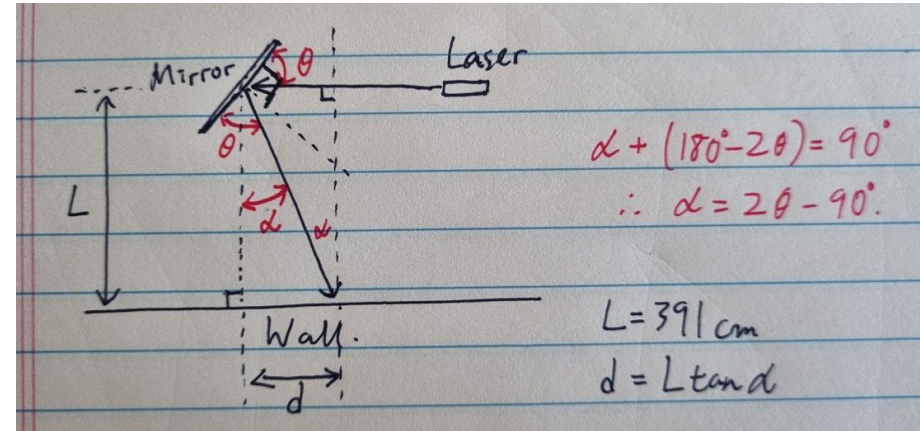
α = Angular position of the beamspot @ wall

L = Distance between optics & wall

d = Linear position of the beamspot @ wall

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

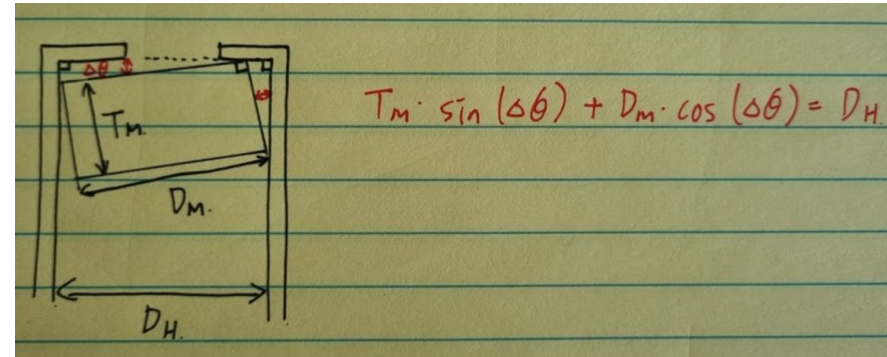
We want all our beamspots within ~10cm!



Hypothesis for the Mirror “Wiggle”

Since holes are slightly bigger than our mirrors, the mirrors can be **mis-aligned**

- Maximum when the mirror is tilted all the way to the edge
- Mirror thickness = 2mm
- Mirror diameter = 5mm
- Hole diameter (or whatever extra space)
 - 5.2mm $\Rightarrow \Delta\theta = 6.73\text{deg}$
 - 5.1mm $\Rightarrow \Delta\theta = 3.07\text{deg}$
 - 5.05mm $\Rightarrow \Delta\theta = 1.48\text{deg}$
- This alone goes beyond our tolerance of $\sim 1\text{deg}$

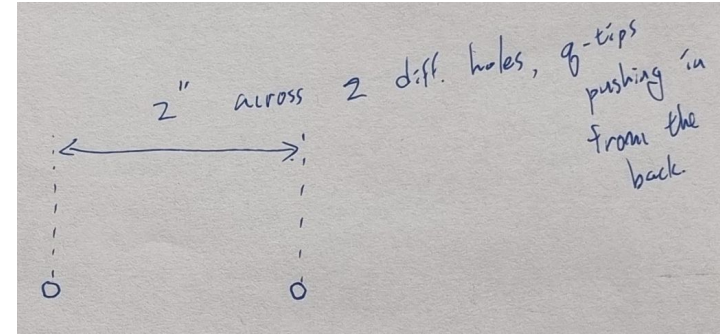


We want the alignment defined by the front-stop surface, not by the small extra space inside the hole. That is, **we need to push the mirrors** from the back.

Quick-fix: Q-tips + Tapes

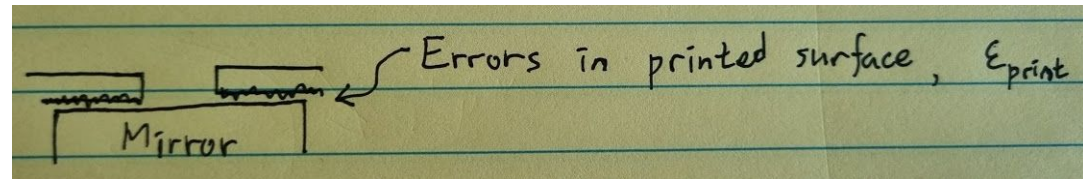
5mm q-tips + tapes to push the mirrors in from the back

- Seemed to work pretty well with 2 holes
- Observed $\Delta d = 2'' \Rightarrow \Delta\theta = 0.366\text{deg}$



If we pushed in properly, the angle is defined by the printed quality of the front-stop surface

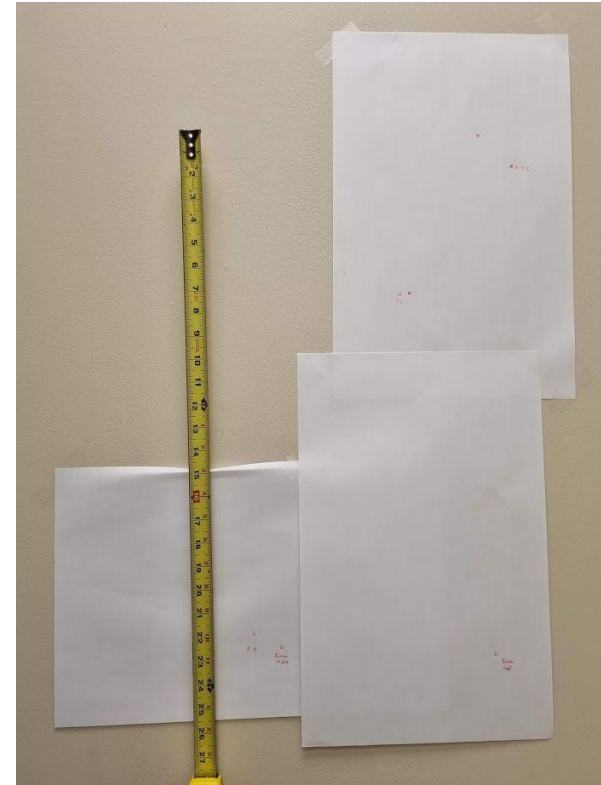
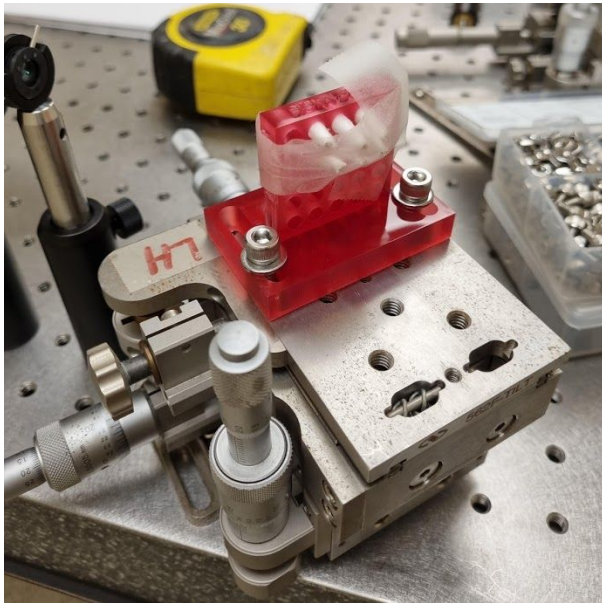
- Printing error of $\epsilon_{\text{print}} = 50\mu\text{m} \Rightarrow \Delta\theta = 0.573\text{deg}$



Scaling the Quick-Fix to multiple mirrors

Tried this with 6 mirrors, but was kind of difficult...

- Over 50cm of max. Deviation
- The tapes are probably not pushing properly



Short-term, Temporary Fix

Use plastic rods with diameter ~5mm, not q-tips

- 3/16" = 4.7625mm
- Will have to cut them ourselves though...
- [McMaster-Carr Link](#)

102 Products

Plastic

How can we improve? | Print | Forward | View catalog pages (24)

<p>Wear-Resistant Easy-to-Machine Delrin® Acetal Resin Rods and Discs Delrin® acetal resin, also known as acetal homopolymer, is stronger and stiffer than acetal copolymer.</p>	<p>Wear-Resistant Easy-to-Machine Acetal Rods and Discs An economical alternative to Delrin® acetal resin, this acetal copolymer offers similar wear resistance.</p>	<p>Wear-Resistant Nylon Rods and Discs Also known as nylon 6/6, this general purpose material is often used for bearings, gears, valve seats, and other high-wear parts.</p>	<p>Slippery MDS-Filled Wear-Resistant Nylon Rods This nylon 6/6 material is modified with MDS for a self-lubricating surface that's more slippery than standard nylon. It's often used in high-friction applications, such as gears and bearings.</p>
<p>Chemical-Resistant PVC Rods and Discs Because PVC resists many acids and alkalis, it's widely used for tanks and in chemical-processing applications. Also known as PVC Type I.</p>	<p>Impact-Resistant Easy-to-Form ABS Rods Because ABS maintains its toughness even after thermofforming, it's often made into storage cases, tote trays, equipment housings, and protective gear.</p>	<p>Polypropylene Rods Because this polypropylene resists swelling when exposed to water, it's often fabricated into containers and parts for laboratory equipment.</p>	<p>Electrical-Insulating Noryl PPO Rods Use Noryl PPO for electrical insulating applications where moisture is a concern. It remains dimensionally stable over time, even when temperatures fluctuate.</p>
<p>Chemical-Resistant Slippery PTFE Rods and Discs Known for its naturally slippery surface, PTFE surpasses most plastics when it comes to chemical resistance and performance in extreme temperatures.</p>	<p>Recycled PTFE Also called reprocessed and mechanical-grade PTFE, this material is an economical alternative to standard PTFE.</p>	<p>Chemical- and Impact-Resistant FEP Rods Just as chemical resistant as PTFE, yet FEP offers greater impact strength. Use it to make valve components and gaskets.</p>	<p>Ultra-Moisture-Resistant PCTFE Often used as gaskets and bearings, this slippery-surface material absorbs virtually no moisture. PCTFE is equivalent to Kevlar and Neolon.</p>
<p>Durable PFA Use PFA in place of PTFE and FEP for durability in repetitive processes, such as pump parts. It is chemical resistant across a wide temperature range.</p>			
Clear Plastic			
<p>Clear Scratch- and UV-Resistant Acrylic Rods and Discs This extruded acrylic offers similar performance as cast acrylic at a lower cost.</p>	<p>Clear Impact-Resistant Polycarbonate Rods and Discs At only half the weight of glass, polycarbonate maintains excellent impact resistance across a wide temperature range. It's comparable to Lexan, Hycod, Tuffak, and Makrolon.</p>	<p>Clear Easy-to-Form PETG Rods PETG can be formed into complex shapes without sacrificing durability.</p>	
Composites			
<p>Multipurpose Flame-Retardant Garolite G-10/FR4 Rods A good all-around choice, Garolite G-10/FR4 is strong, machinable, and electrically insulating. It meets UL 94 V-0 for flame retardance.</p>	<p>High-Temperature Garolite G-11 Rods Offering higher strength and better heat resistance than Garolite G-10/FR4, Garolite G-11 is suitable for continuous use in elevated temperatures.</p>	<p>Halogen-Free Garolite G-10 Rods Use Garolite G-10 in place of Garolite G-10/FR4 for applications that are sensitive to halogen, such as in nuclear plants. It's strong, machinable, and electrically insulating.</p>	<p>Structural FRP Fiberglass Rods An alternative to wood in structural applications, FRP fiberglass is strong and lightweight.</p>
<p>Arc-Resistant GPO3 Fiberglass Rods Offering excellent arc and track resistance, this GPO3 fiberglass is often used for electrical applications in humid environments.</p>	<p>Easy-to-Machine Hard Fiber Rods Hard fiber is the easiest composite to machine, making it good for creating custom parts. Also known as vulcanized fiber.</p>		

Long-term Solution

- Additional part behind with tapped holes
- Screws with plastic tips
 - Extra-soft nylon tips to minimize contact damage
 - McMaster-Carr Link

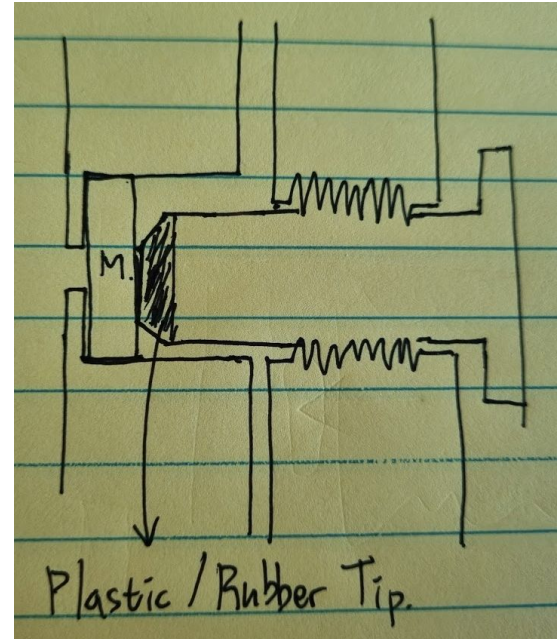
Alloy Steel Nylon-Tip Set Screws



An extra-soft nylon tip minimizes the damage that can occur from metal-on-metal contact. Use these set screws on soft surfaces such as aluminum. The body has a black-oxide finish to resist corrosion in dry environments. Length listed does not include the tip.

For technical drawings and 3-D models, click on a part number.

Lg.	Di.	Lg.	Tip Temp. Range, °F	Color	Drive Size	Hardness	Specifications Met	Pkg. Qty.	Pkg.
Black-Oxide Alloy Steel									
2-56									
1/8"	0.031"	0.031"	-50° to 250°	Green	0.035"	Rockwell C28	ASME B18.3	10	94115A051 \$13.80
1/4"	0.031"	0.031"	-50° to 250°	Green	0.035"	Rockwell C28	ASME B18.3	10	94115A056 14.11
4-40									
1/8"	0.063"	0.031"	-50° to 250°	Green	0.050"	Rockwell C28	ASME B18.3	10	94115A103 11.66
3/16"	0.063"	0.031"	-50° to 250°	Green	0.050"	Rockwell C28	ASME B18.3	10	94115A105 8.34
1/4"	0.063"	0.031"	-50° to 250°	Green	0.050"	Rockwell C28	ASME B18.3	10	94115A106 6.85
3/8"	0.063"	0.031"	-50° to 250°	Green	0.050"	Rockwell C28	ASME B18.3	10	94115A107 8.34
6-32									
1/8"	0.063"	0.031"	-50° to 250°	Green	1/16"	Rockwell C28	ASME B18.3	10	94115A142 13.12
3/16"	0.063"	0.031"	-50° to 250°	Green	1/16"	Rockwell C28	ASME B18.3	10	94115A143 8.40
1/4"	0.063"	0.031"	-50° to 250°	Green	1/16"	Rockwell C28	ASME B18.3	10	94115A144 6.71
3/8"	0.063"	0.031"	-50° to 250°	Green	1/16"	Rockwell C28	ASME B18.3	10	94115A164 7.92
1/2"	0.063"	0.031"	-50° to 250°	Green	1/16"	Rockwell C28	ASME B18.3	10	94115A184 8.48
8-32									
1/8"	0.094"	0.047"	-50° to 250°	Green	5/64"	Rockwell C28	ASME B18.3	10	94115A188 9.06
3/16"	0.094"	0.047"	-50° to 250°	Green	5/64"	Rockwell C28	ASME B18.3	10	94115A189 8.40
1/4"	0.094"	0.047"	-50° to 250°	Green	5/64"	Rockwell C28	ASME B18.3	25	94115A190 17.39
3/8"	0.094"	0.047"	-50° to 250°	Green	5/64"	Rockwell C28	ASME B18.3	10	94115A192 8.12
1/2"	0.094"	0.047"	-50° to 250°	Green	5/64"	Rockwell C28	ASME B18.3	10	94115A198 8.78
5/8"	0.094"	0.047"	-50° to 250°	Green	5/64"	Rockwell C28	ASME B18.3	10	94115A196 9.17



Summary

- 5mm mirrors cannot fit through 5.0mm or smaller holes
- Friction holding will NOT work, even with the 5.2mm holes
 - 5.2mm holes allow significant angular deviation, order of few degrees
- 5.4mm holes are loose, no apparent friction
- We need to push in from the back
 - If properly pushed to the front surface, we should get:
 - $\Delta\theta = 0.573\text{deg}$ for 5mm mirrors
 - $\Delta\theta = 0.955\text{deg}$ for 3mm mirrors
 - Additional layer with tapped holes + plastic-tip screws
 - Additional board with male rods + compressible buffers (rubber disks?)
- We should get to 2nd round of 3D printing