Mechanical Testing of Mirror Holder MHTestAn

Overview & Preliminary Results from June 9th

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SLAC MAGIS Group Meeting
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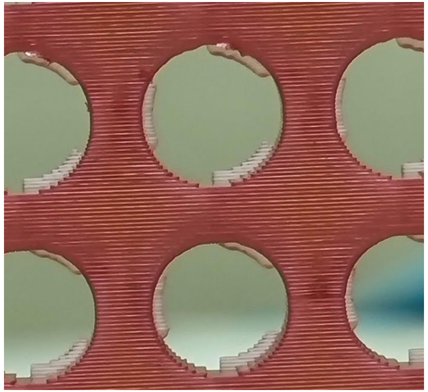
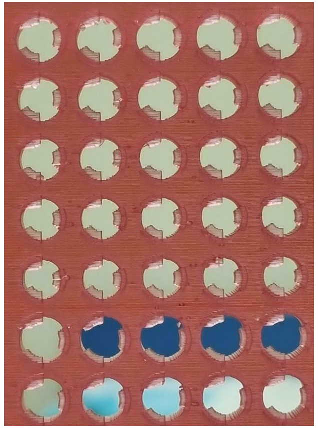
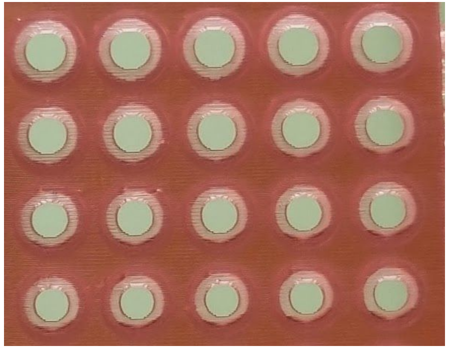
3D Printed MHTestAn Boards



Visual Inspection

- Holes
  - Can see the finite granularities
  - The holes are not actually "circular"
  - This makes **the innermost dimensions smaller**
  - Smallest feature is ~100um
- Front-stops
  - Full ring (*n*=1) seems smooth
  - Other smaller legs have issues
  - Potentially due to printing directions

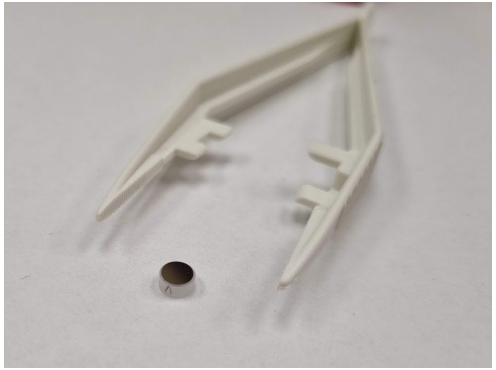


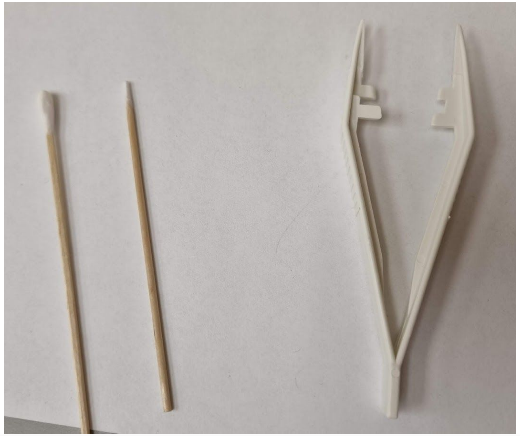


Handling & Inserting the Mirrors

Handling tools

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





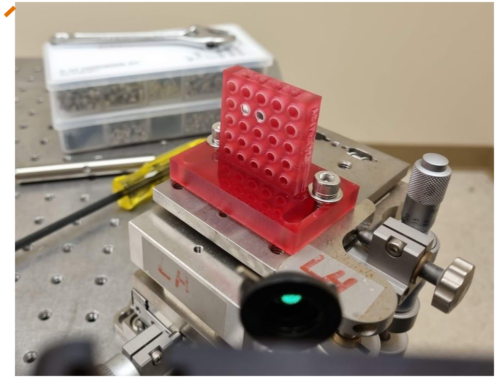
Experience from inserting a few so far

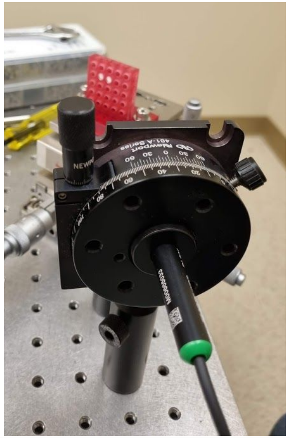
- Hole diameters: {4.6, 4.8, 5.0, 5.2, 5.4} mm
- 5.0mm or smaller: do NOT fit
- 5.2mm: quite tight to push in, but stable at
  - Some mirrors + holes won't fit together
- 5.4mm: slides in smoothly without friction

Lab Settings

520nm USB Laser

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





Sensitivity to Angular Alignment

$\boldsymbol{\theta}$ = Mirror alignment (w.r.t. laser)

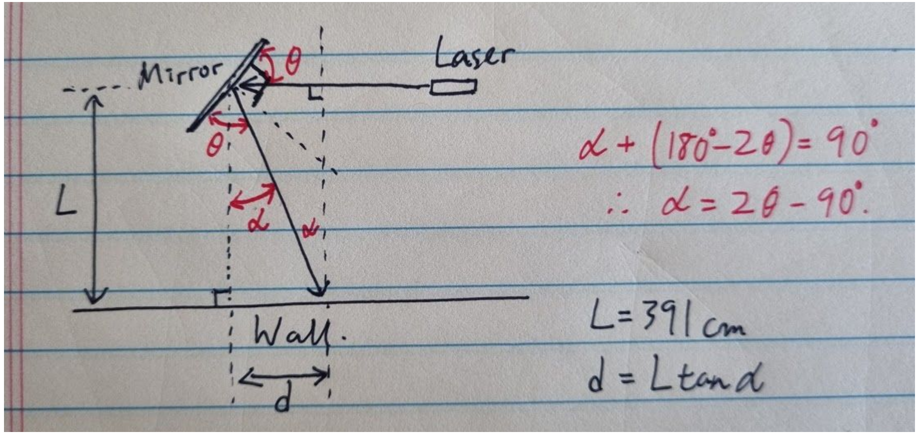
$\boldsymbol{\alpha}$ = Angular position of the beamspot @ wall

L = Distance between optics & wall

d = Linear position of the beamspot @ wall

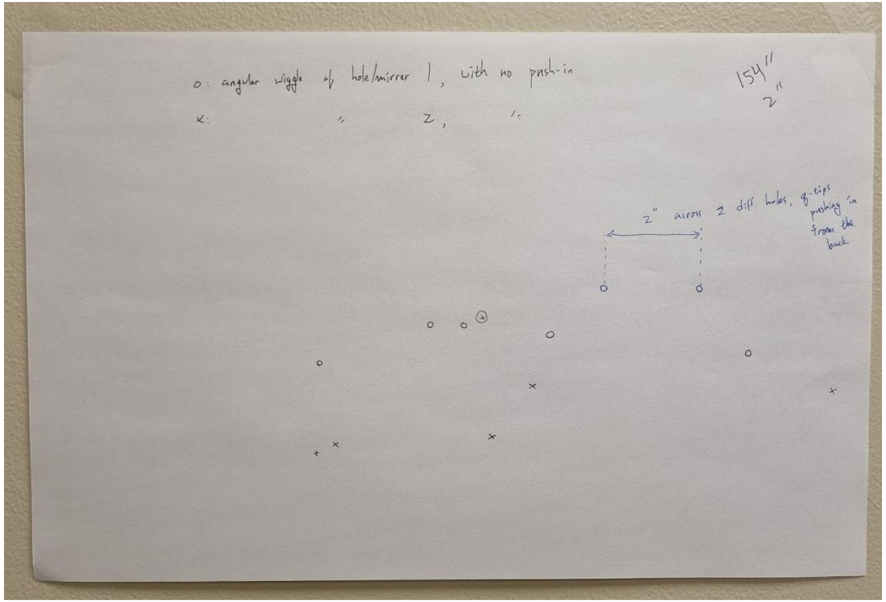
$$\Delta\theta = 0.1^\circ \implies \Delta d = 13.66\,\text{mm}$$

We want all our beamspots within ~10cm!



Mirror "Wiggle" inside 5.2mm Holder

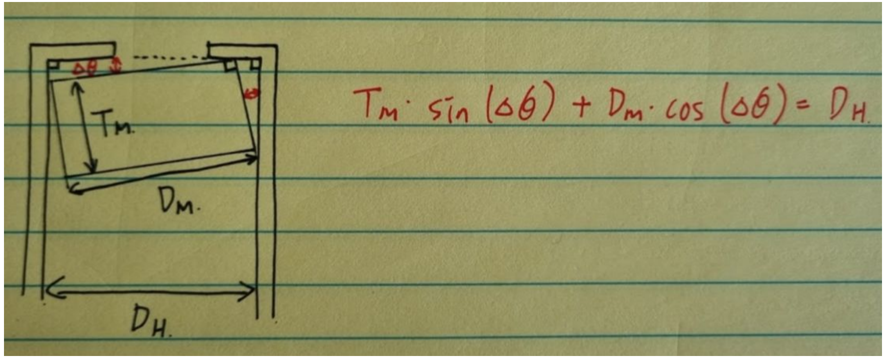
- With the small q-tip, it was **easy to push the edges and tilt** the mirror inside a holder
  - This was felt throughout other practice insertions
  - Observed with beam and measured with 2 different holes and mirrors
- This caused a huge deviation in beamspot
  - At max. difference: $\Delta d_{max} = 30\text{cm}$
    $\Rightarrow \Delta\alpha_{max} = 4.4\text{deg} \Rightarrow \Delta\theta_{max} = 2.2\text{deg}$
- Simple friction-holding **will NOT work**
- The mirrors can easily wiggle
  a few degrees with small force or
  as an error across mounting processes



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 ⇒ $\Delta\theta$ = 6.73deg
    - 5.1mm ⇒ $\Delta\theta$ = 3.07deg
    - 5.05mm ⇒ $\Delta\theta$ = 1.48deg
- This alone goes beyond our tolerance of ~1deg

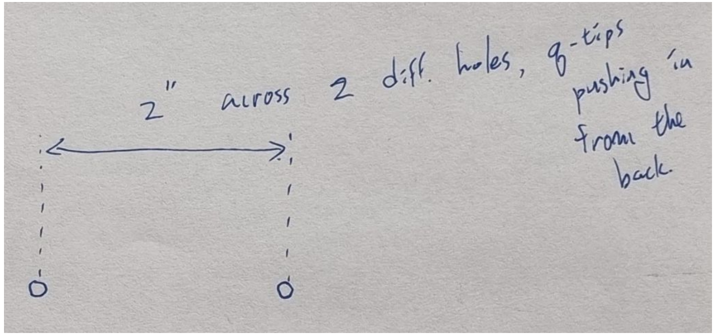


We want the alignment defined by the front-stop surface, not by the small extra space inside the hole. That is, **we need to push the mirrors** from the back.

Quick-fix: Q-tips + Tapes

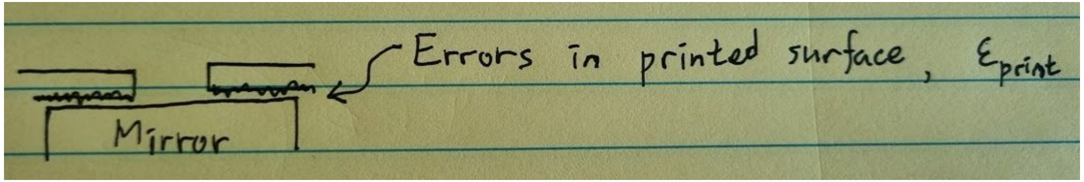
5mm q-tips + tapes to push the mirrors in from the back

- Seemed to work pretty well with 2 holes
- Observed Δd = 2” $\Rightarrow$ $\Delta\theta$ = 0.366deg



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

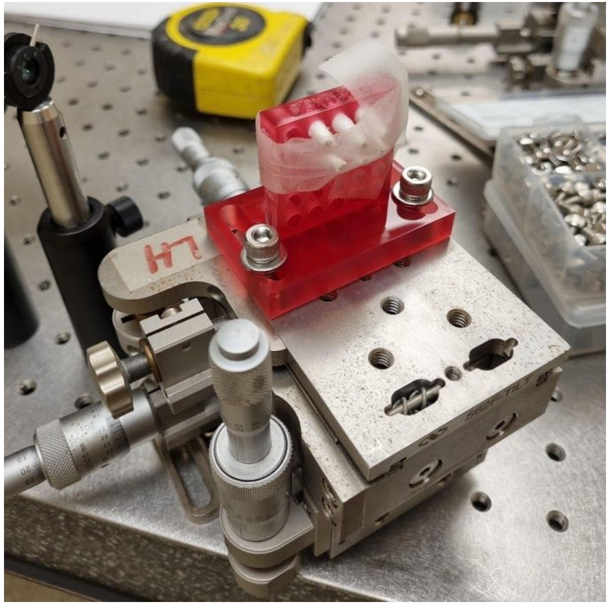
- Printing error of $\varepsilon_{\text{print}}$ = 50um $\Rightarrow$ $\Delta\theta$ = 0.573deg

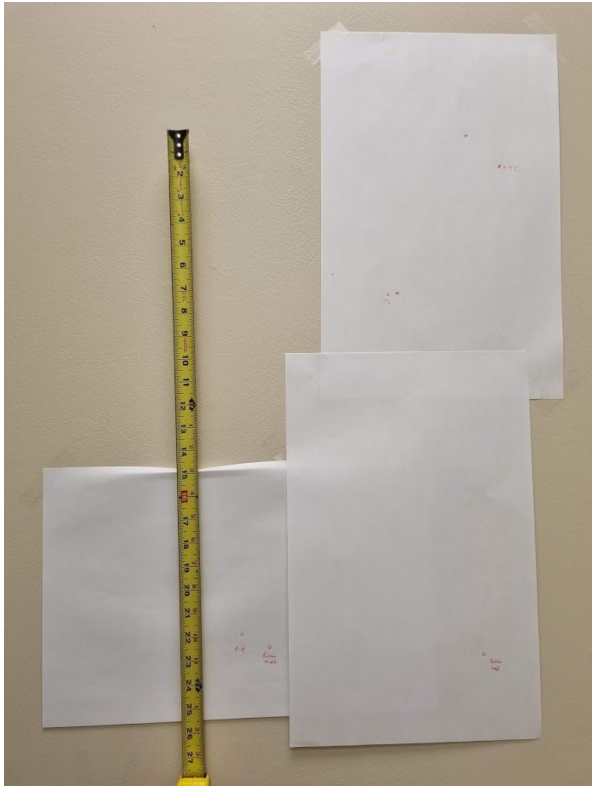


Scaling the Quick-Fix to multiple mirrors

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

Long-term Solution

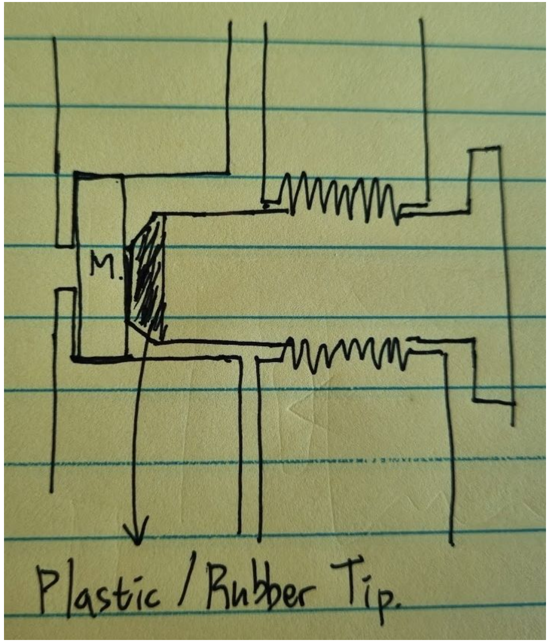
- Additional part behind with tapped holes
- Screws with plastic tips
  - Extra-soft nylon tips to minimize contact damage
  - McMaster-Carr Link

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.

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

Lg.	Tip Dia.	Tip 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



Conclusion

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:
    - $\Delta\theta$ = 0.573deg for 5mm mirrors
    - $\Delta\theta$ = 0.955deg 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