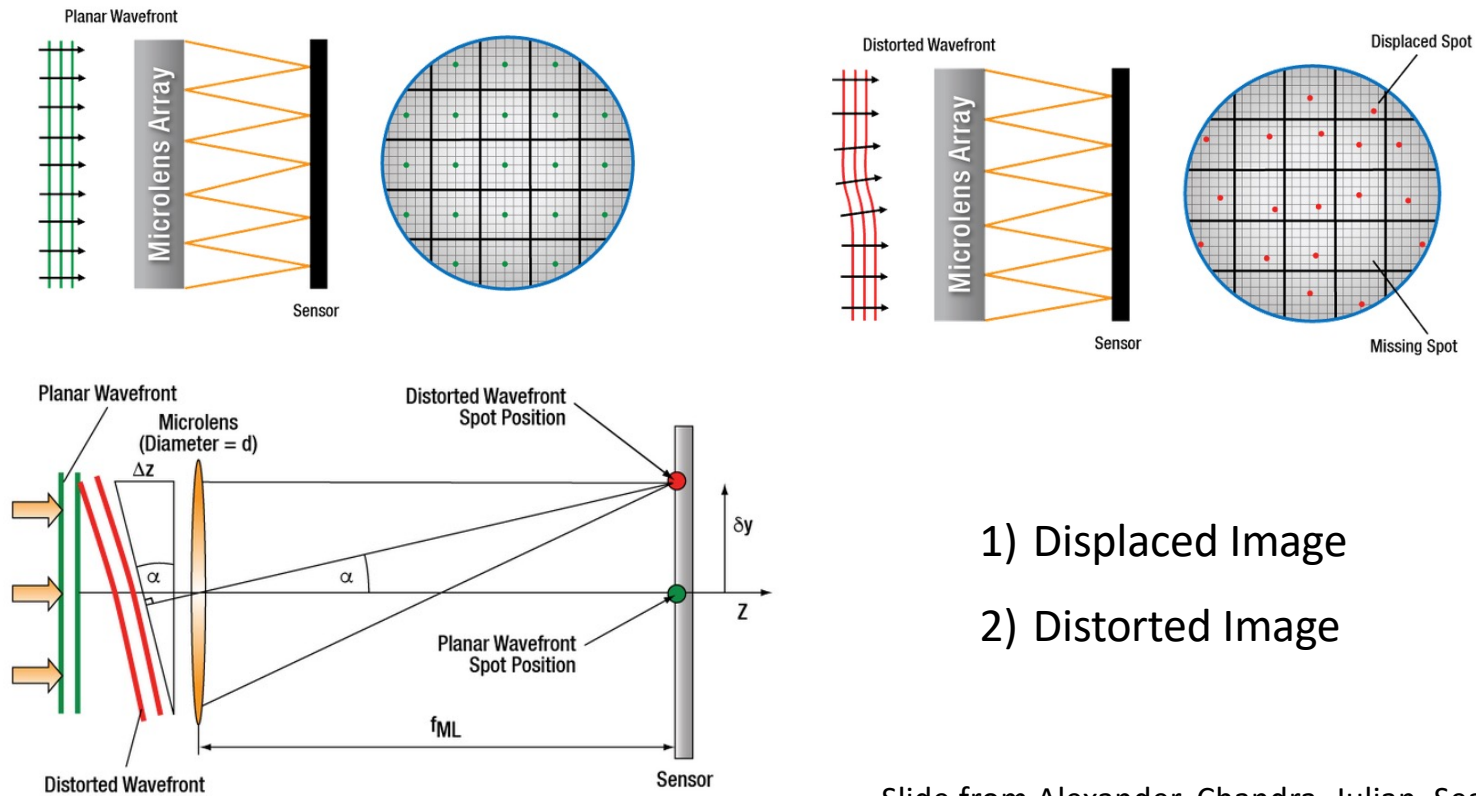


ePIC pfRICH Aerogel Imaging Aerogel with a Microlens

Matt Posik
Temple University

Microlens Concept

Images courtesy of Thorlabs

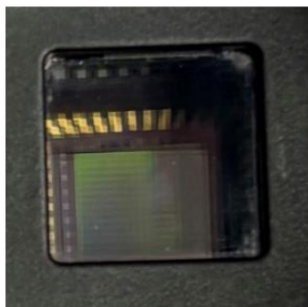


- 1) Displaced Image
- 2) Distorted Image

Slide from Alexander, Chandra, Julian, Sean [study](#)

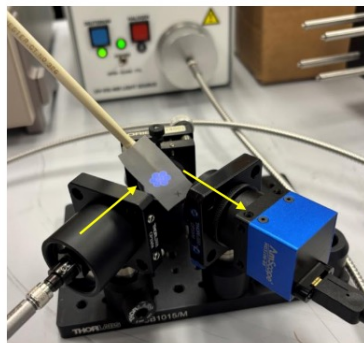
Microlens

Using CMOS camera with multi-lens array (MLA) to image beamspot reflected from mirror.

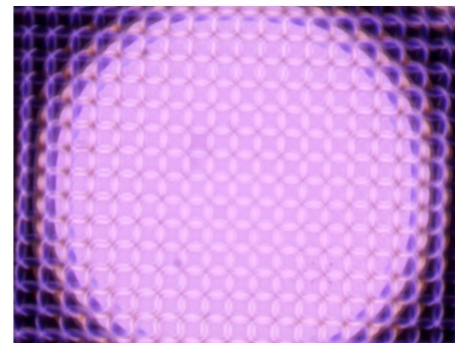
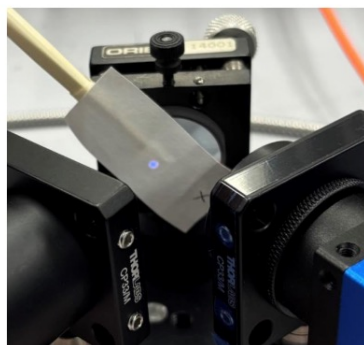


View through MLA of camera sensor

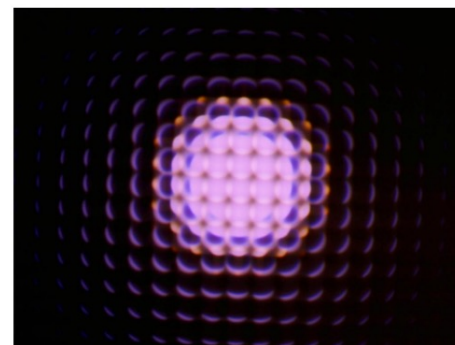
Input fiber:
bundle



Input fiber:
200um



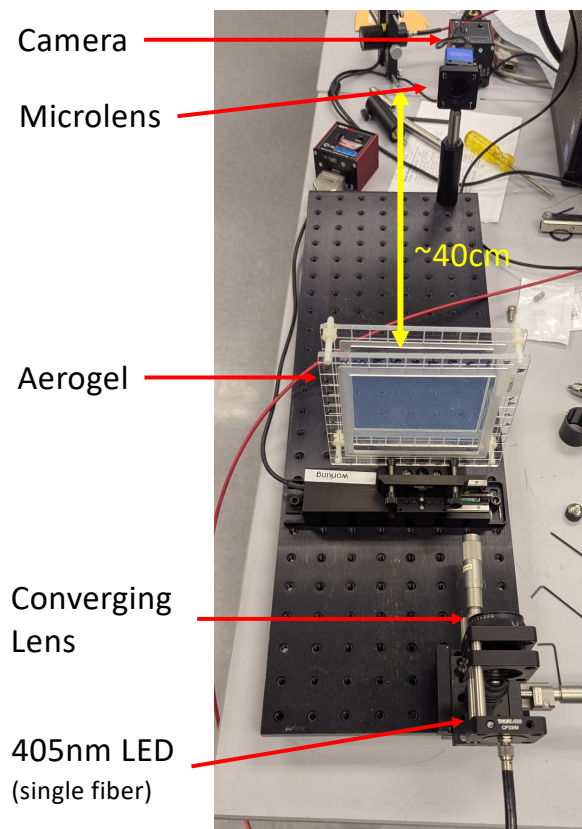
Central fiber (1/7)



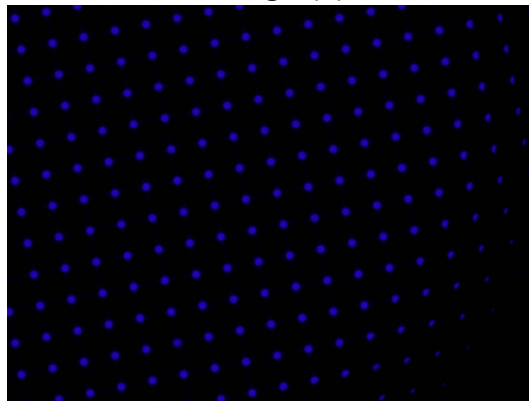
Single 200 um fiber

Slide from Sean Stoll: [see presentation](#)

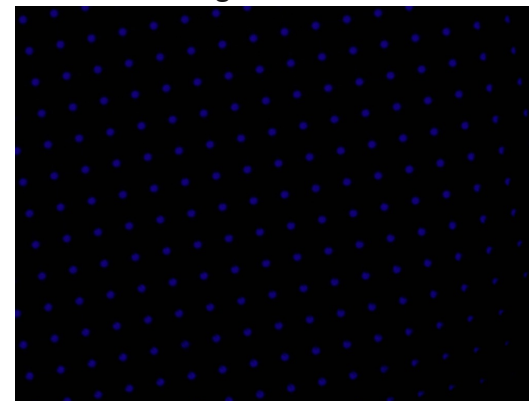
Transmission



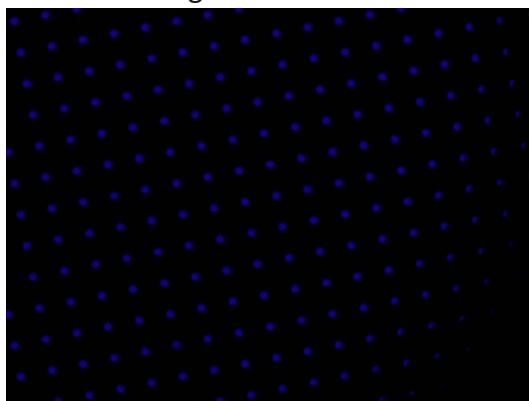
No Aerogel (b)



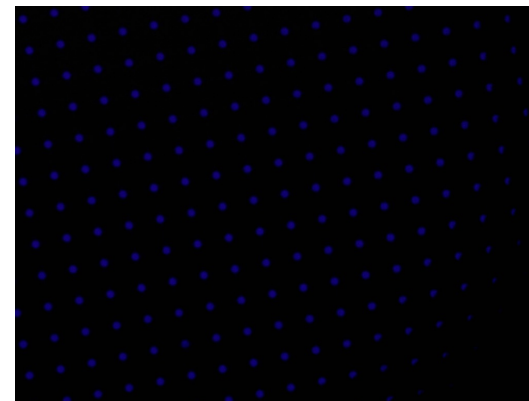
Aerogel Position 1b



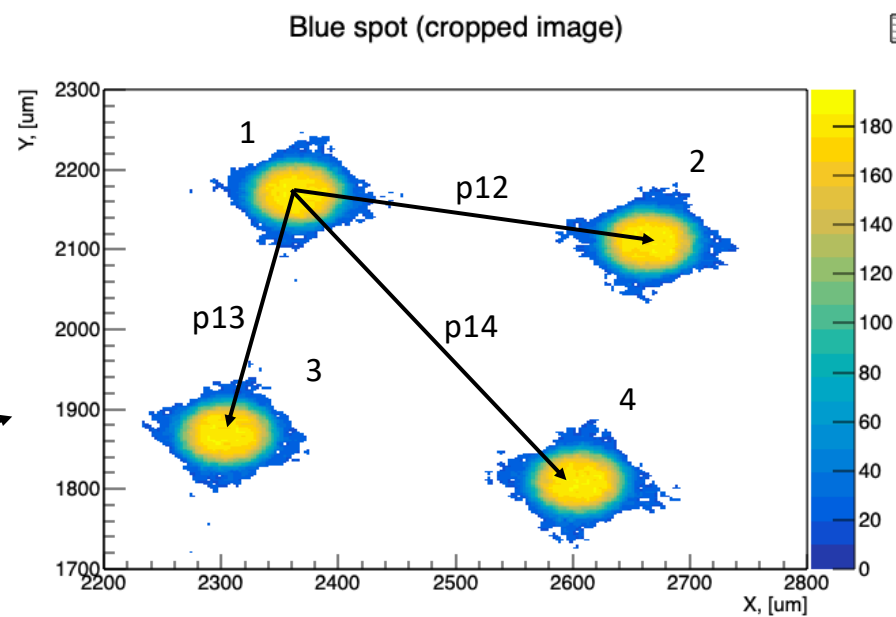
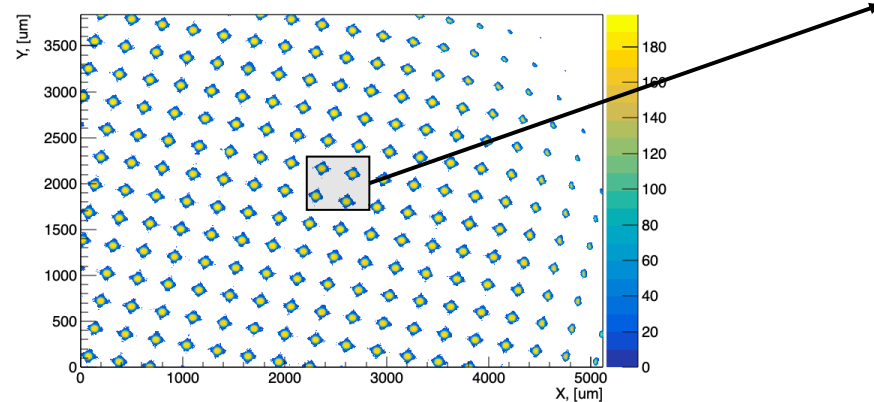
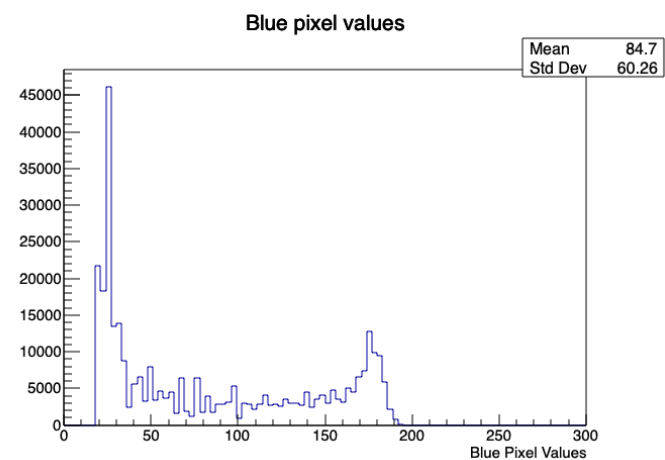
Aerogel Position 2b



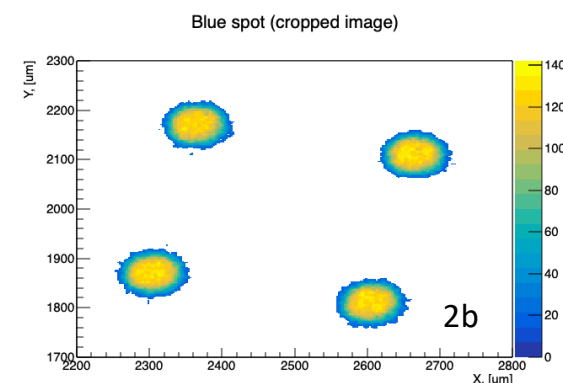
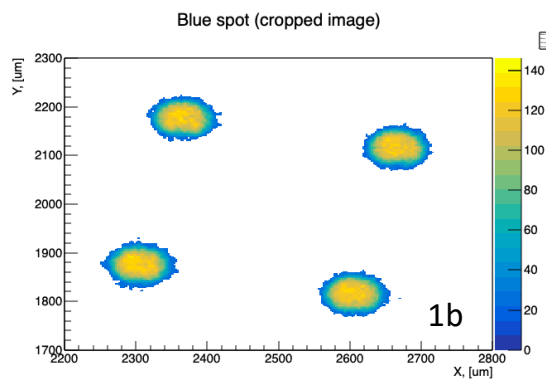
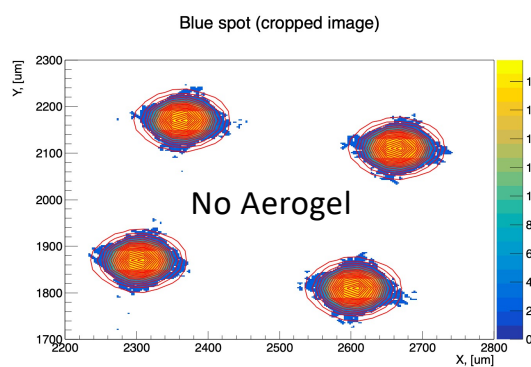
Aerogel Position 3b



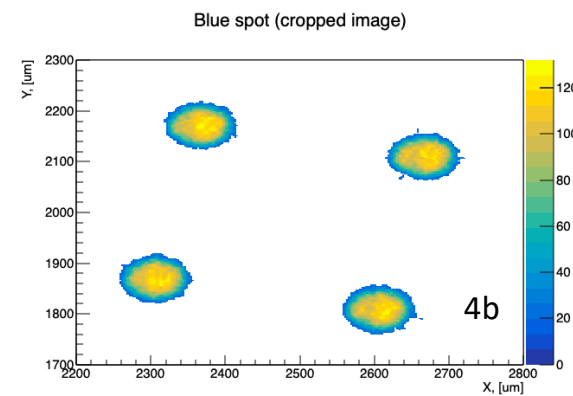
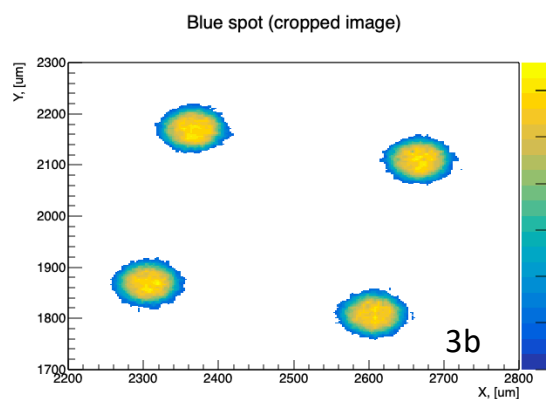
Transmission: No Aerogel



Transmission: Spots with Aerogel



- Fit spots with a 2D Gauss w/ correlation parameter to assess
 - Displacements
 - Pitch
 - Broadening



Transmission: 2D Fit Results (Spot 1)



- Fairly large $\frac{\chi^2}{NDf} \sim 60$

No Aerogel (b)

```
*****
Minimizer is Minuit2 / Migrad
Chi2                =      483986
NDf                 =       7405
Edm                 =  9.09818e-07
NCalls              =       246
A                   =      235.872 +/- 0.922297
x0                  =     2364.82 +/- 0.0778018
y0                  =      2170.2 +/- 0.0773443
sigma_x             =      37.5501 +/- 0.09625
sigma_y             =      37.3743 +/- 0.0962251
rho                 =    -0.00718659 +/- 0.00729593
*****
```

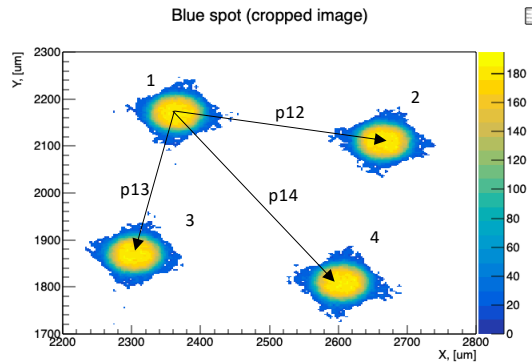
Aerogel (1b)

```
*****
Minimizer is Minuit2 / Migrad
Chi2                =      257609
NDf                 =       4614
Edm                 =  5.22196e-08
NCalls              =       227
A                   =      153.492 +/- 0.837083
x0                  =     2365.81 +/- 0.11886
y0                  =     2177.24 +/- 0.102899
sigma_x             =      37.6868 +/- 0.168788
sigma_y             =      33.5048 +/- 0.1409
rho                 =    -0.0946045 +/- 0.0118921
*****
```

Aerogel (2b)

```
*****
Minimizer is Minuit2 / Migrad
Chi2                =      288900
NDf                 =       4937
Edm                 =  1.68794e-06
NCalls              =       245
A                   =      158.257 +/- 0.816167
x0                  =     2364.66 +/- 0.108998
y0                  =     2170.88 +/- 0.109697
sigma_x             =      36.7175 +/- 0.151809
sigma_y             =      37.0534 +/- 0.152994
rho                 =      0.10782 +/- 0.0110808
*****
```

Transmission: Displacements and Pitches



- Small centroid displacements generally $\sim 1 \mu\text{m}$ or less
- Largest displacement ($\sim 10 \mu\text{m}$) from aerogel 1b image
 - Position is closest to aerogel edge
- Pitches appear stable

➤ Error on position from fit $\sim 0.1 \mu\text{m}$

➤ $\frac{\chi^2}{Ndf} \sim 60$

Spot	dx [um]	dy [um]	dsx [um]	dsy [um]
1	0.99	7.04	0.141	-3.869
2	0.96	6.96	-0.695	-3.206
3	0.44	6.68	-0.451	-3.836
4	0.63	6.41	-0.035	-3.223

Aerogel 1b				
1	-0.16	0.68	-0.8286	-0.3205
2	-0.21	0.02	-0.7929	-0.5754
3	0.32	1.55	-1.1705	-1.2057
4	0.19	1.29	-0.6604	-0.5442

Aerogel 2b				
1	1.33	-0.31	-0.5603	-1.0837
2	1.61	-0.14	-1.451	-0.7033
3	1.05	-0.48	-0.8529	-1.3112
4	1.51	-0.21	-1.3101	-1.6064

Aerogel 3b				
1	2.32	0.72	0.3408	-1.7568
2	1.49	-0.03	1.2052	-1.5392
3	1.81	-0.25	0.8149	-2.4101
4	2.52	-0.02	-0.0419	-1.7203

spots	xpitch [um]	ypitch [um]
p12	300.694	60.015
p14	240.099	361.483
p13	60.587	300.980

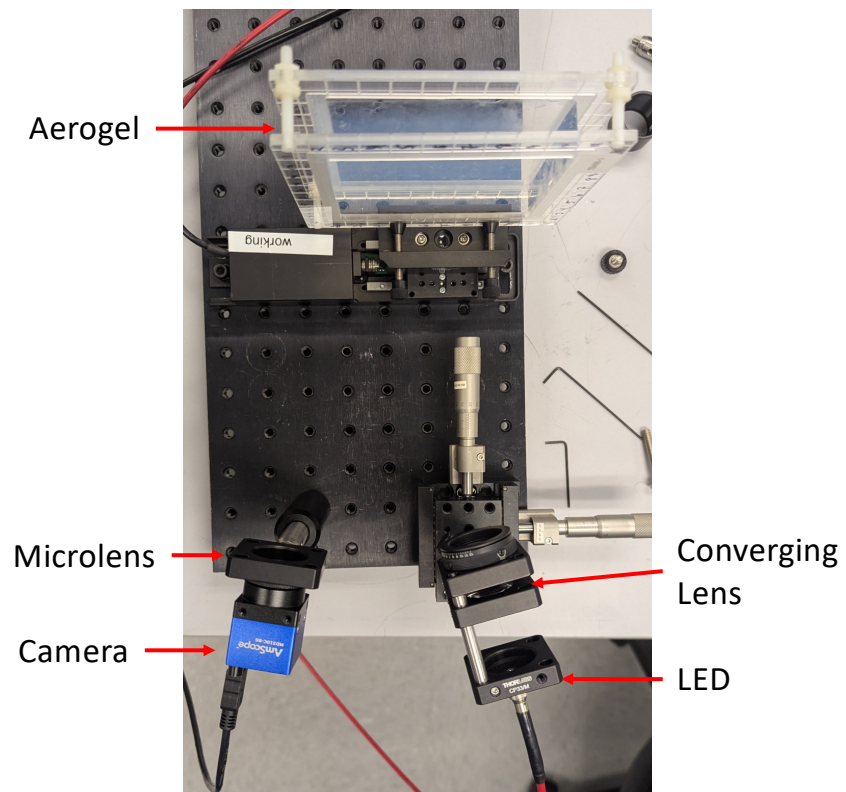
p12	300.658	60.116
p14	239.552	361.850
p13	60.955	301.616

p12	300.641	60.692
p14	240.580	360.617
p13	60.233	300.366

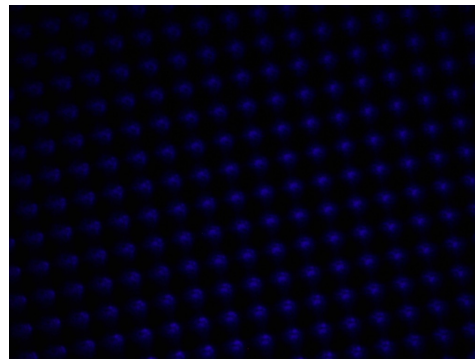
p12	300.967	59.856
p14	239.818	361.663
p13	60.416	300.878

p12	299.856	60.779
p14	239.593	362.456
p13	60.3867	301.719

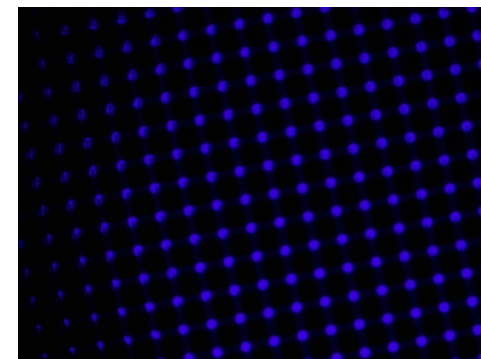
Reflection



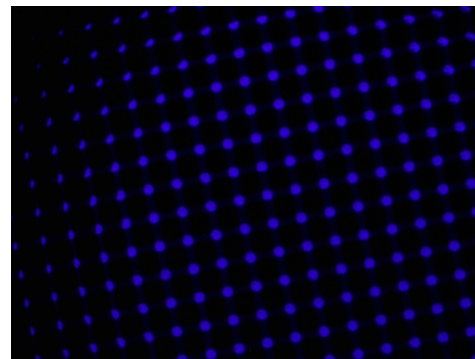
Aerogel Reflect Position 1b



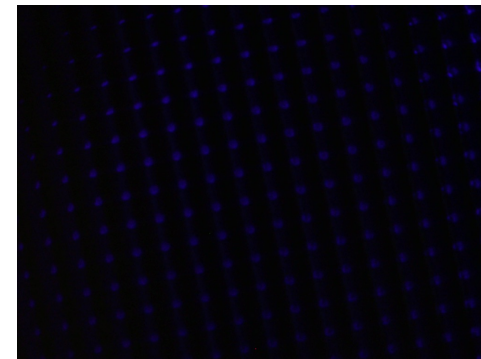
Aerogel Reflect Position 2b



Aerogel Reflect Position 3b



Aerogel Reflect Position 4b



- More variation seen in reflected images
 - Intensity and shape (see video scan in backup)

Microlens Next Steps



☐ Transmission

- Current analysis approach doesn't seem statistically precise enough to assess deviation
 - Include all full spots from the image in analysis and try using fit to describe changes to the overall spot grid
 - Try increasing sensitivity by increasing the lever arm from ~40cm to 200cm
- Can setup also be used to assess forward scattering?
 - Measure spot broadening vs diaphragm opening.

☐ Reflection

- Use current analysis approach to take first look at a few spots.
 - This method seems more sensitive than the transmission method
 - Extend analysis to include all full spots in the image
- Repeat measurement at different angles of incidence
- Can this setup be used to assess Brewster's angle?

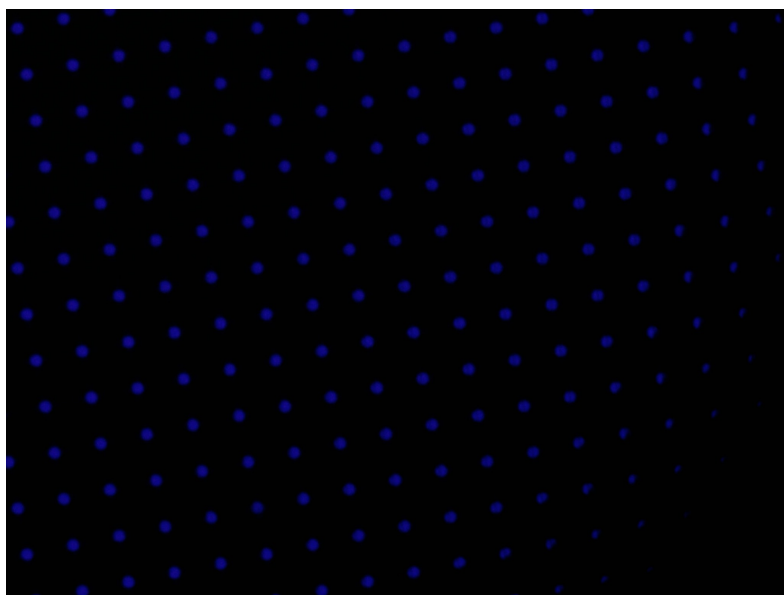
Backup



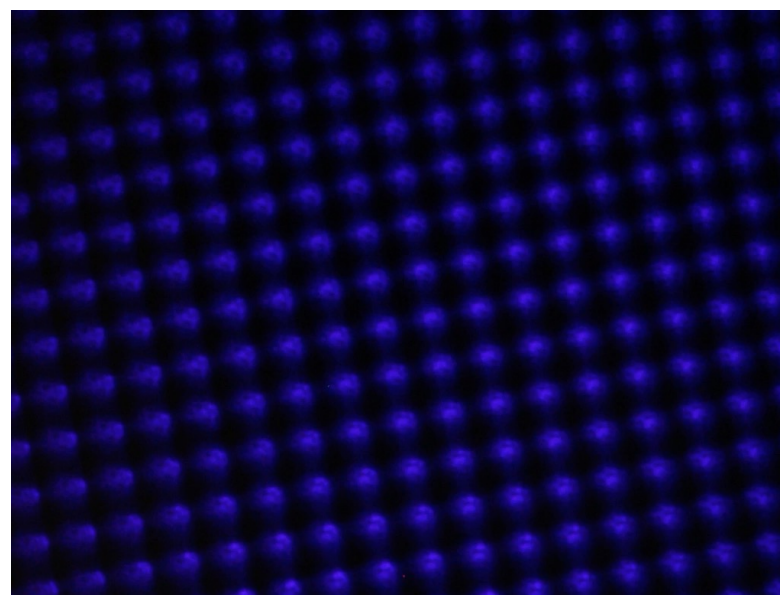
Aerogel Scanning Video



Transmission Scan



Reflection Scan



Transmission: 2D Fit Results



No Aero									
dot	x [um]	x error [um]	y [um]	y error [um]	sx [um]	sx error [um]	sy [um]	sy error [um]	
1	2364.82	0.0778	2170.2	0.07734	37.546	0.096074	37.3741	0.09609	
2	2665.51	0.07817	2110.17	0.07779	37.868	0.096653	37.1314	0.09613	
3	2604.92	0.07717	1808.71	0.07754	37.8211	0.0958024	37.9789	0.09724	
4	2304.23	0.07736	1869.22	0.07677	37.5358	0.0947159	37.5545	0.09424	
Aero 1b									
1	2365.81	0.11886	2177.24	0.1029	37.6868	0.168592	33.5048	0.14072	
2	2666.47	0.11797	2117.13	0.10516	37.1727	0.166338	33.9257	0.14491	
3	2605.36	0.11658	1815.39	0.10452	37.3702	0.1684	34.1433	0.14649	
4	2304.86	0.11288	1875.63	0.10201	37.5012	0.154585	34.3314	0.13903	
Aero 2b									
1	2364.66	0.109	2170.88	0.1097	36.7174	0.151632	37.0536	0.15282	
2	2665.3	0.10785	2110.19	0.1064	37.0751	0.148097	36.556	0.14864	
3	2605.24	0.10618	1810.26	0.1064	36.6506	0.145976	36.7732	0.1462	
4	2304.42	0.10628	1870.51	0.10636	36.8754	0.145296	37.0103	0.14755	
Aero 3b									
1	2366.15	0.11615	2169.89	0.11446	36.9857	0.166907	36.2904	0.16323	
2	2667.12	0.11529	2110.03	0.1165	36.417	0.164578	36.4281	0.16726	
3	2605.97	0.11626	1808.23	0.11708	36.9682	0.170212	36.6677	0.17333	
4	2305.74	0.11224	1869.01	0.11322	36.2257	0.161919	35.9481	0.15838	
Aero 4b									
1	2367.14	0.12221	2170.92	0.11321	37.8868	0.182065	35.6173	0.16688	
2	2667	0.12853	2110.14	0.11355	39.0732	0.190285	35.5922	0.16638	
3	2606.73	0.12523	1808.46	0.11135	38.636	0.18431	35.5688	0.15758	
4	2306.75	0.1173	1869.2	0.11272	37.4939	0.176097	35.8342	0.15885	