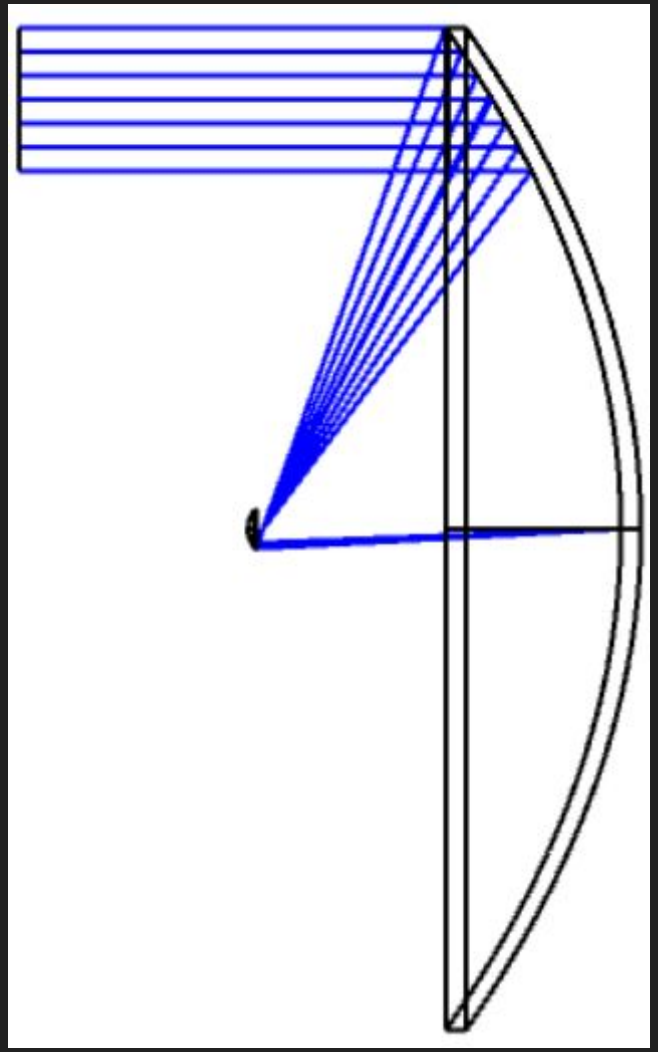
Zemax Optics Studio

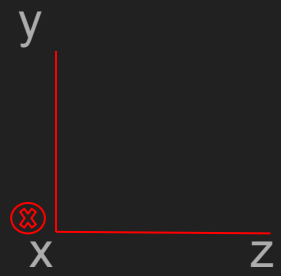
Declan

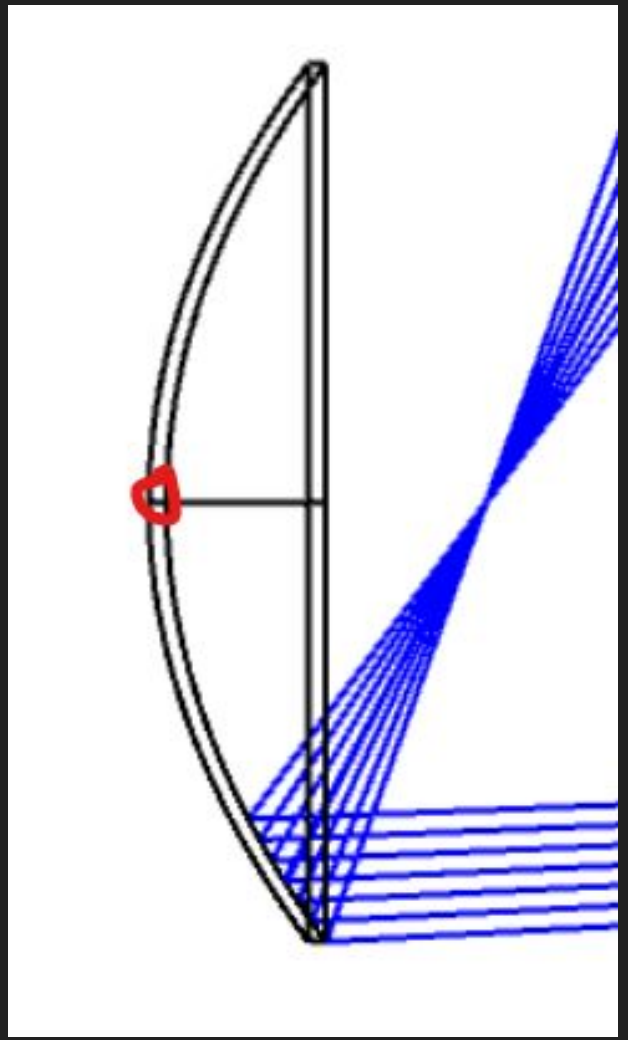
Full

Setup

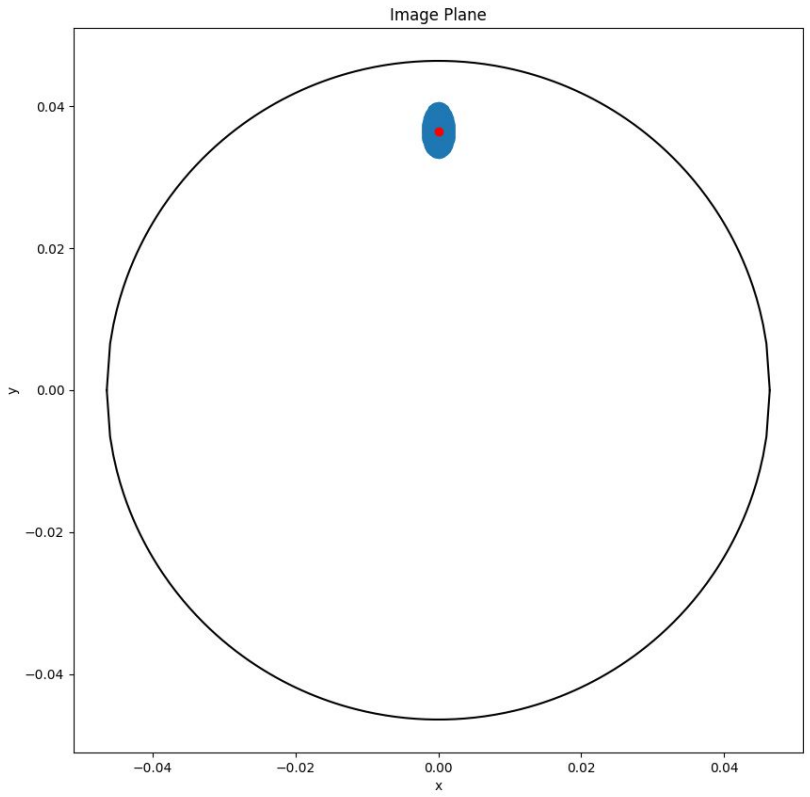


Tip around:

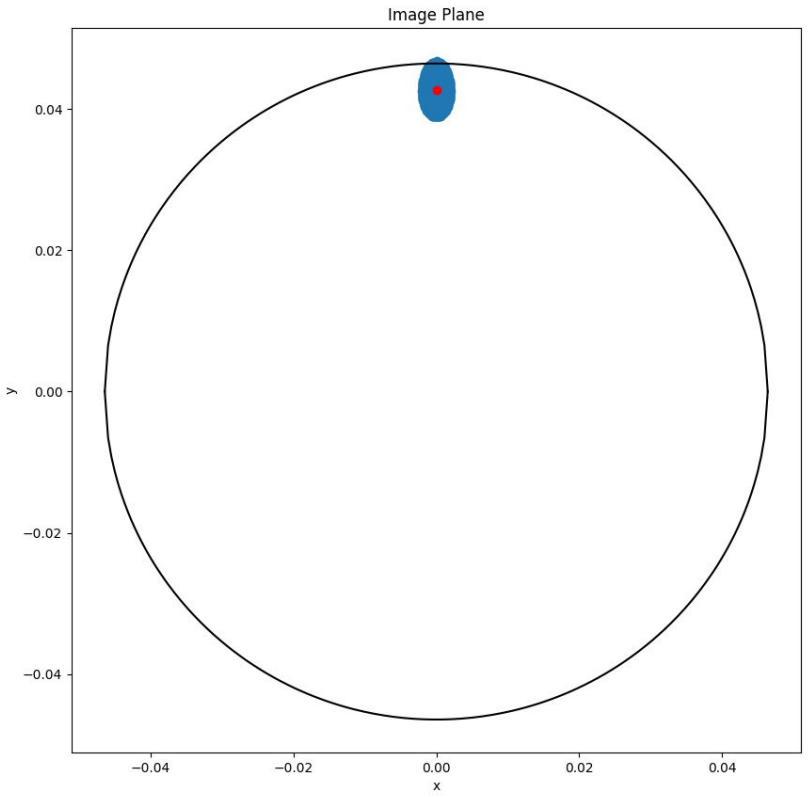




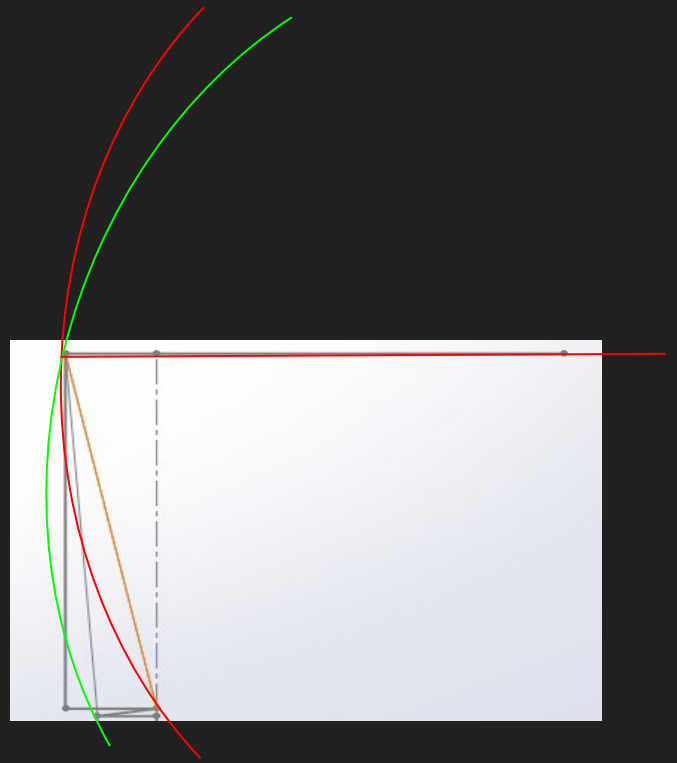
0.012 degrees



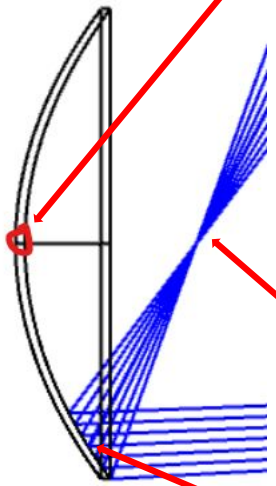
0.014 degrees



Tip (rotation around the x axis) acting like subaperture



Red: Zero tip angle
Green: arbitrary tip angle



Focus

Where the rays hit the ellipse

Center of the Ellipse

49.98

72.69°

9.72°

Arbitrary Theta: This is the tip angle

Focus

Chief ray

61.80

61.80

59.00

10.48

10.23

2.26

18.38

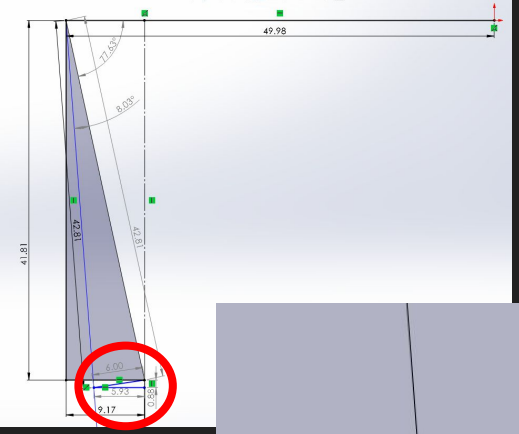
Where the rays hit the ellipse: No tip angle

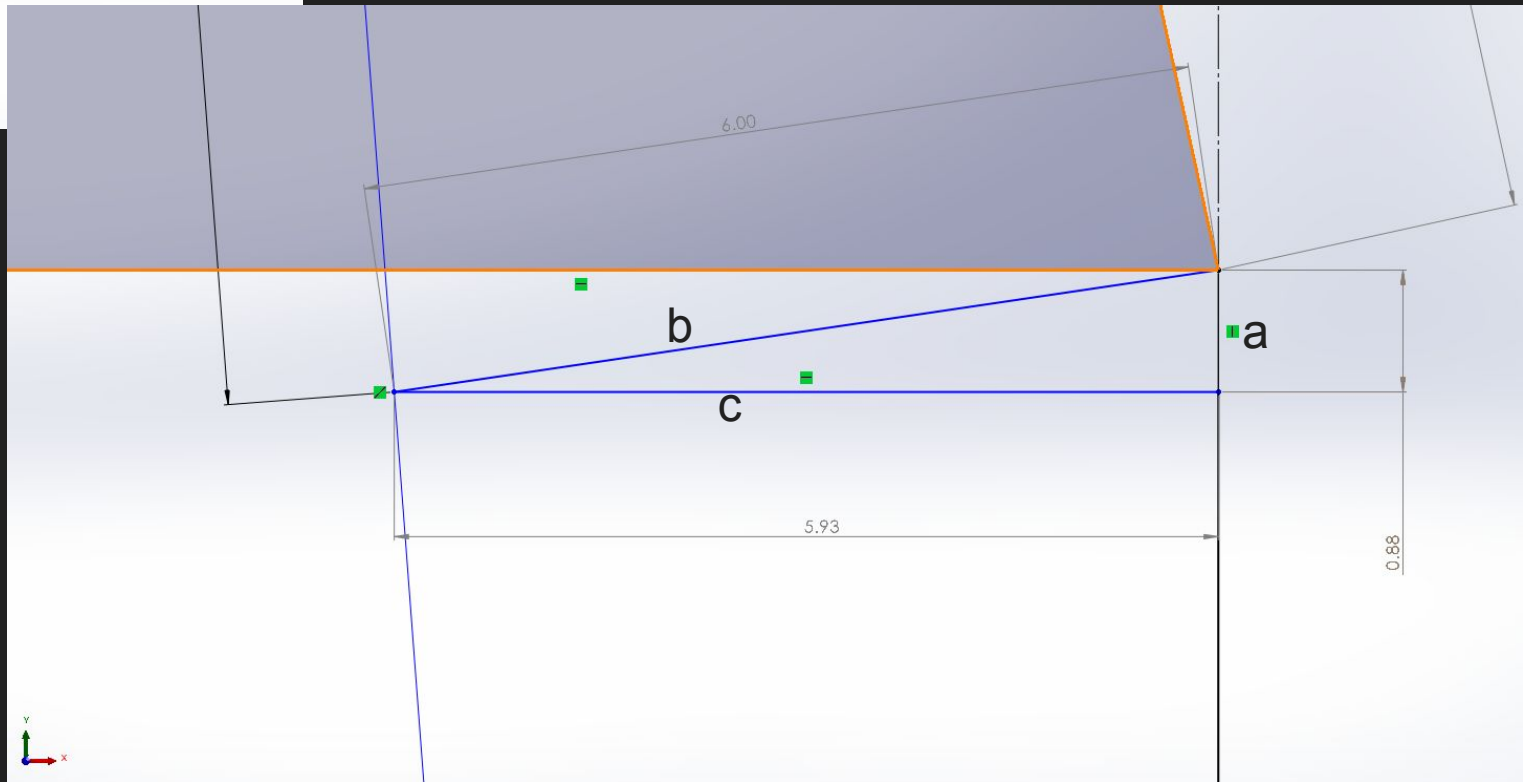
Where the rays hit the ellipse: Arbitrary tip angle

Tip then Decenter or Decenter then tip?

- Decenter then tip because Zemax code follows the local axis so if tip happens first then the decenters will be at respect to the tipped angles
- The Math detailed in the next few slides holds still because whatever decenter is done to the subaperture is done in the same manner to the center of the ellipse too, which is where the Zemax code acts out from

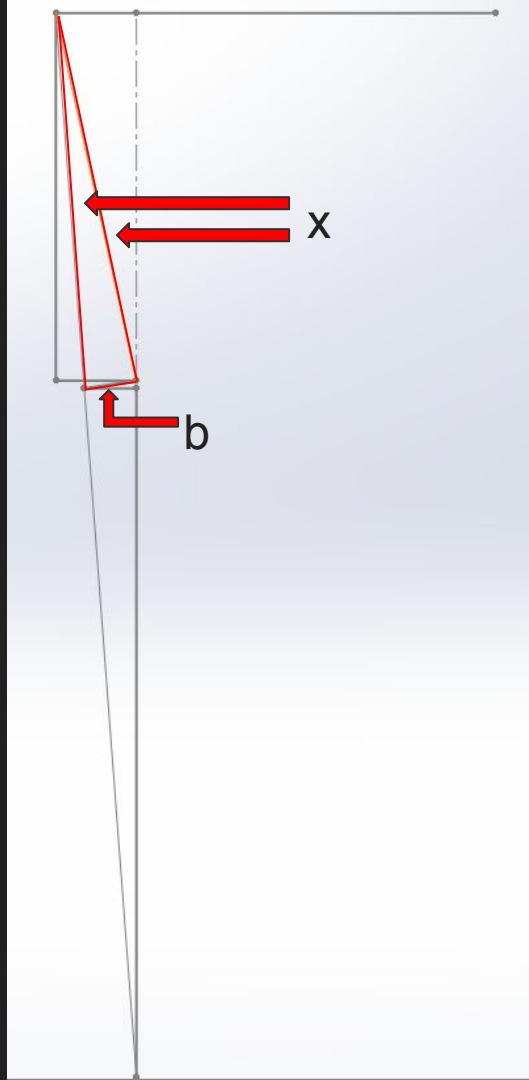
If we find “c” and “a” then we can find the decentering needed to reposition the tilted ellipse back to where the original ellipse was but at a tilted angle





Red Isosceles Triangle

- Two long legs are known can be determined on a ray trace on a zero tip angle ellipse
- The angle between the two legs is the tip angle
- Using law of cosines the short leg, “b”, can be found



Pink Right Triangle

Whole Hypotenuse leg = 18.3831 / cos(72.69+tip angle)

- Abbreviate to WH

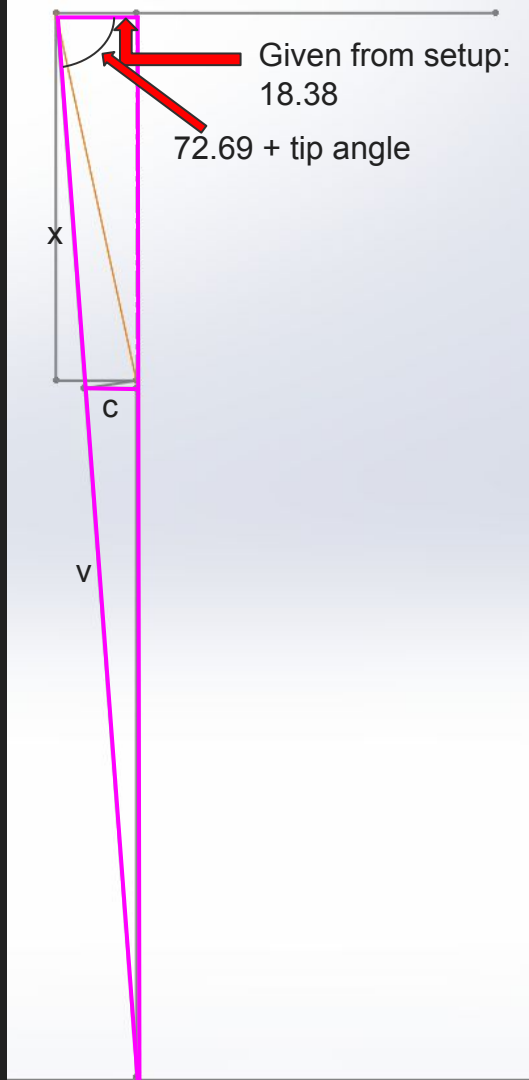
x = large leg of red isosceles triangle

Similar triangles give us:

WH/(WH-x) = 18.38/c

This gives us “c” which then can give us “a”

through pythagorean theorem



UPDATE! MUST USE DECENTER THEN TILT

- Afterwards use tilt then decenter
- (Earlier triangles don't fully demonstrate this but same geometry is valid)

Secret Sauce

```
#Moving the Ellipse around
SURP el, BOR, 0                 # decenter then tip
SURP el-1, THIC, decz(p)        # thickness (decenter z) only before surface, read above for why
SURP el, BDY, decy(p)           # decenter in y before surface
SURP el, BTX, tip(p)            # tip before surface
SURP el, AOR, 1                 # tip then decenter
SURP el, ADY, -decy(p)          # decenter in y after surface
SURP el, ATX, -tip(p)           # tip after surface (resets to normal coordinates)

#SURP el, BTY, tilt(q)          # tilt before surface
#SURP el, ATY, -tilt(q)         # tilt after surface (resets to normal coordinates)
UPDATE ALL                      # updates the graphic and makes sure process is accepted
```

Next two slides are wrong

- It moves the image off of the image plane so therefore it cannot be added to other images on the image plane
- It moves the image off the image plane by creating a new image plane at some z distance from the original image plane.

- Working on fixing this

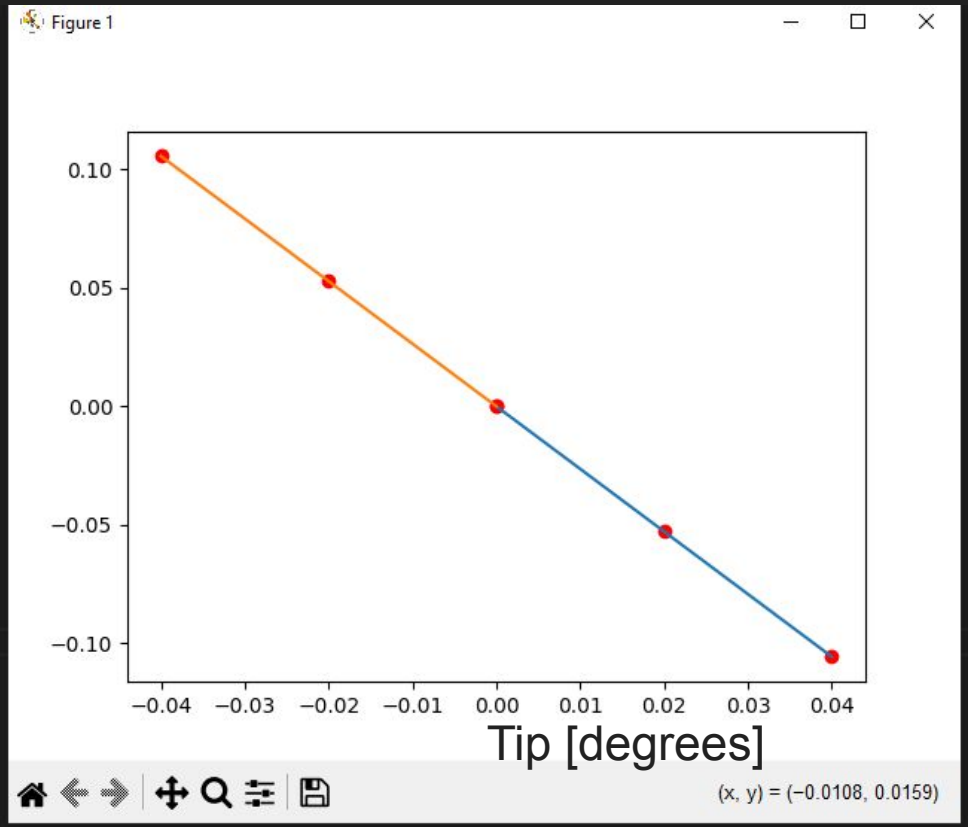
Empirical Findings

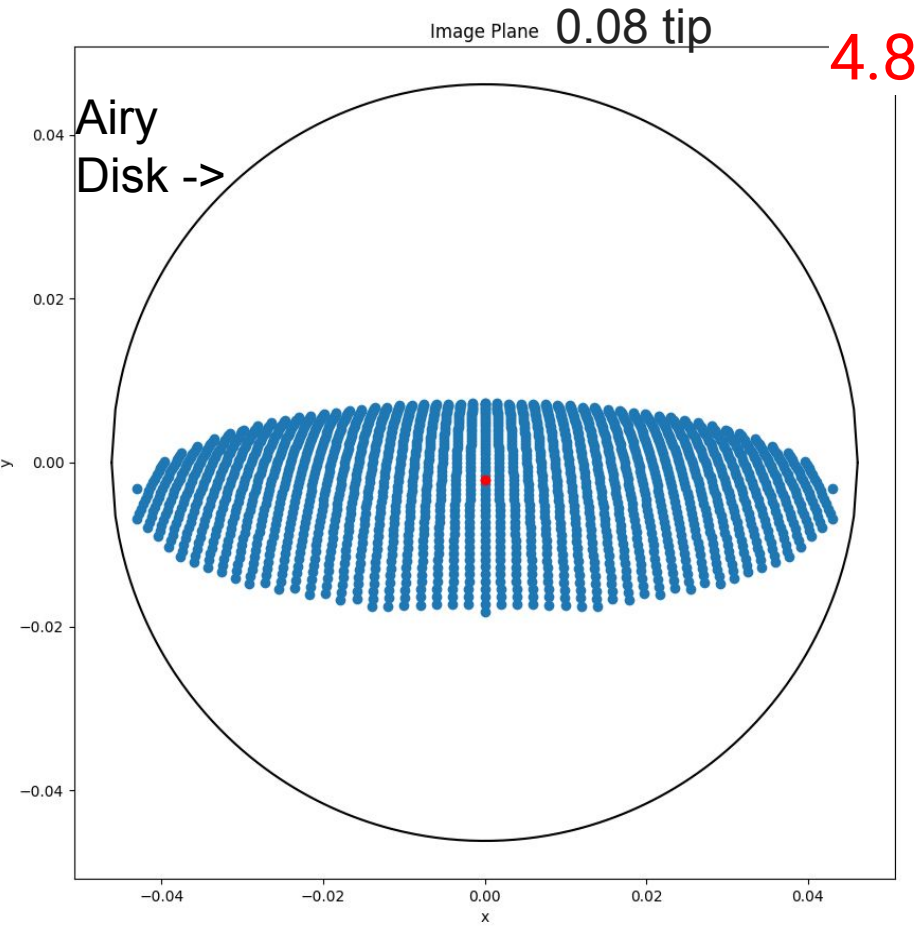
Tip and how much correction to get within a 1e-8 of (0,0,0) on image plane

It is LINEAR! *mind blown*

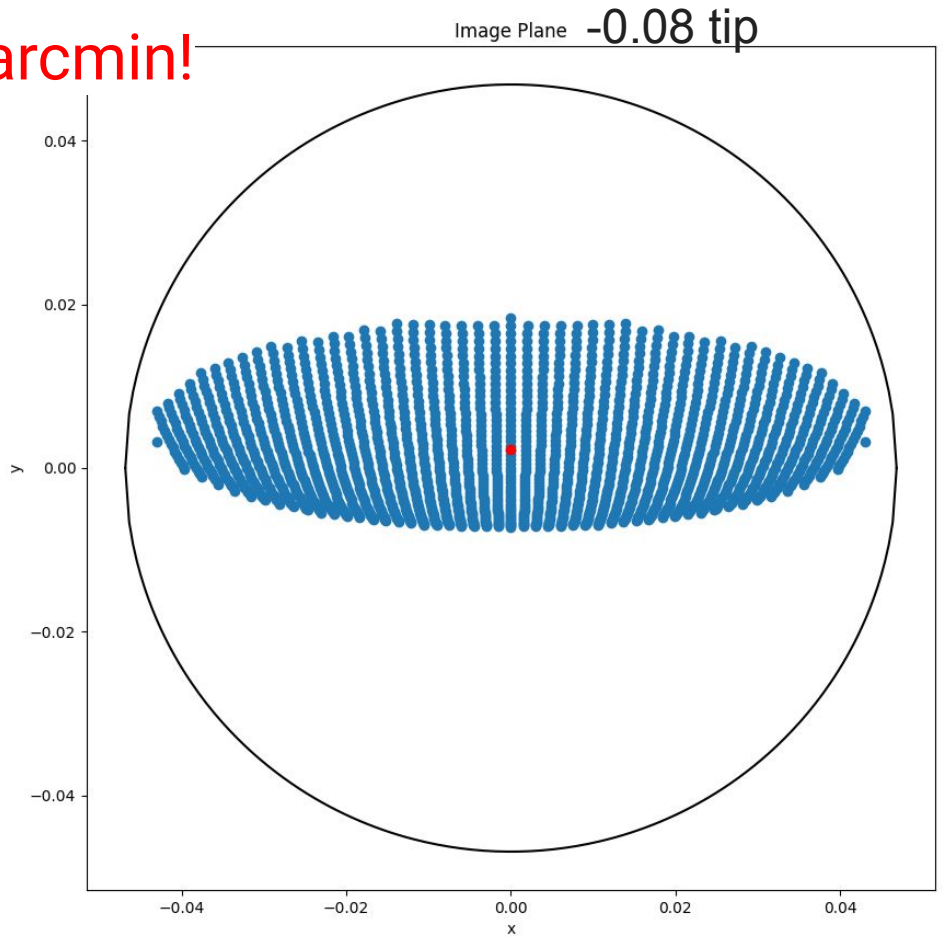
Zemax > TIPvsZ > ...

```python
import matplotlib.pyplot as plt
from scipy.stats import linregress

tip1 = [0.04, 0.02, 0]
tip2 = [0, -0.02, -0.04]
#  8 zeros
z1 = [-0.105746402, -0.052862231, 0]
z2 = [0, 0.052840187, 0.1056585]

slope1, intercept1, r_value1, p_value1, std_err1 = linregress(tip1, z1)
y_fit1 = [slope1 * x + intercept1 for x in tip1]
slope2, intercept2, r_value2, p_value2, std_err2 = linregress(tip2, z2)
y_fit2 = [slope2 * x + intercept2 for x in tip2]

print(slope1, intercept1)
print(slope2, intercept2)

plt.plot(tip1, y_fit1)
plt.plot(tip2, y_fit2)
plt.scatter(tip1,z1,color='red')
plt.scatter(tip2,z2,color='red')
plt.show()


print("test1", slope1*0.04 + intercept1)
print("test2", slope2*-0.04 + intercept2)
```





4.8 arcmin!

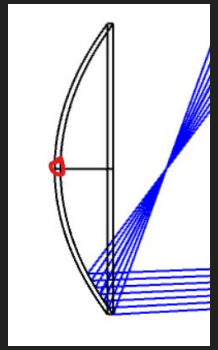


Tolerance from line of fit is 1e-4 (should be at least 1e-6 or better)

RMS vs compensated tip angle

Airy disk radius vs comp tip angle

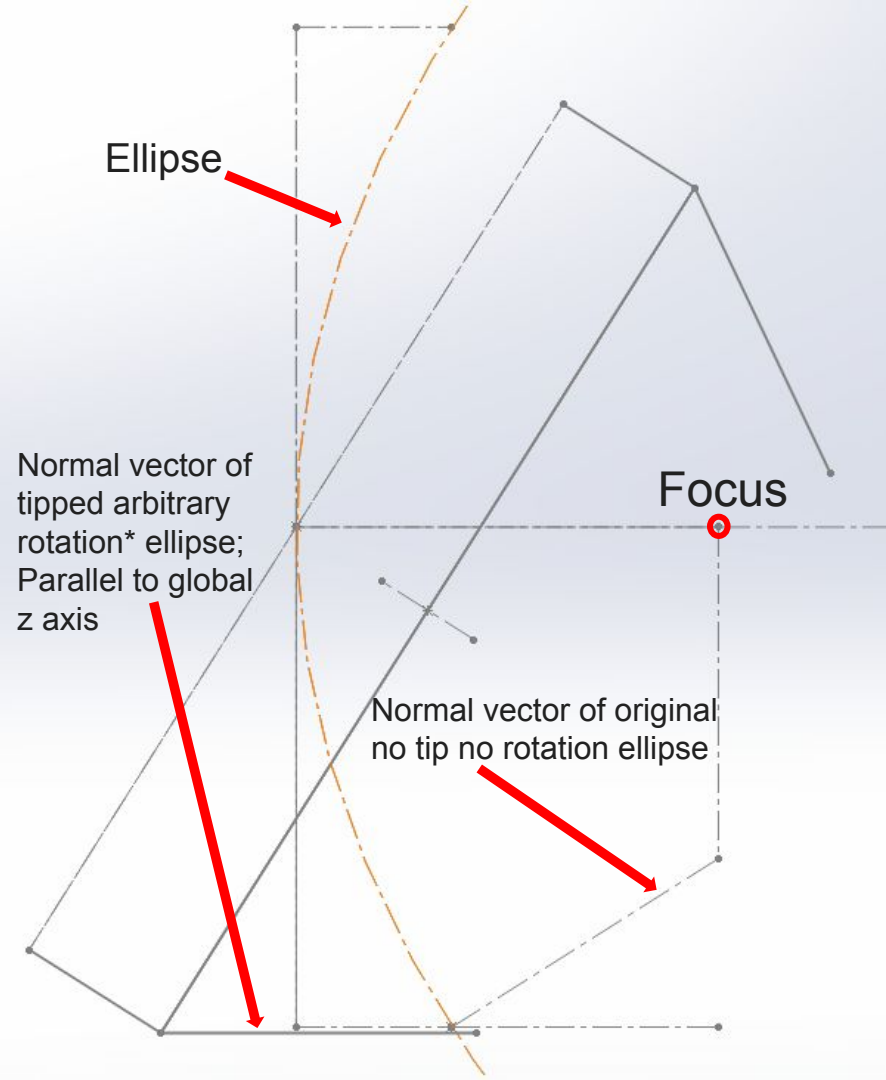
Clocking Error (yaw)



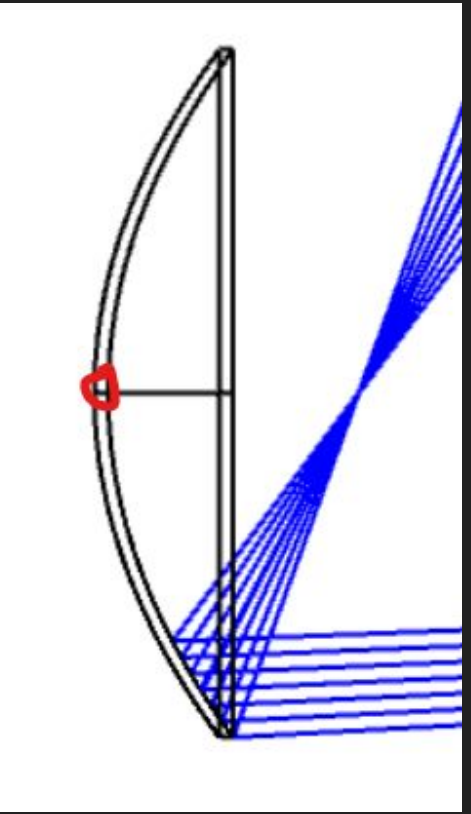
Decenter then the idea is to align global z axis with normal of subaperture by a tip then rotate in z then do negative same tip

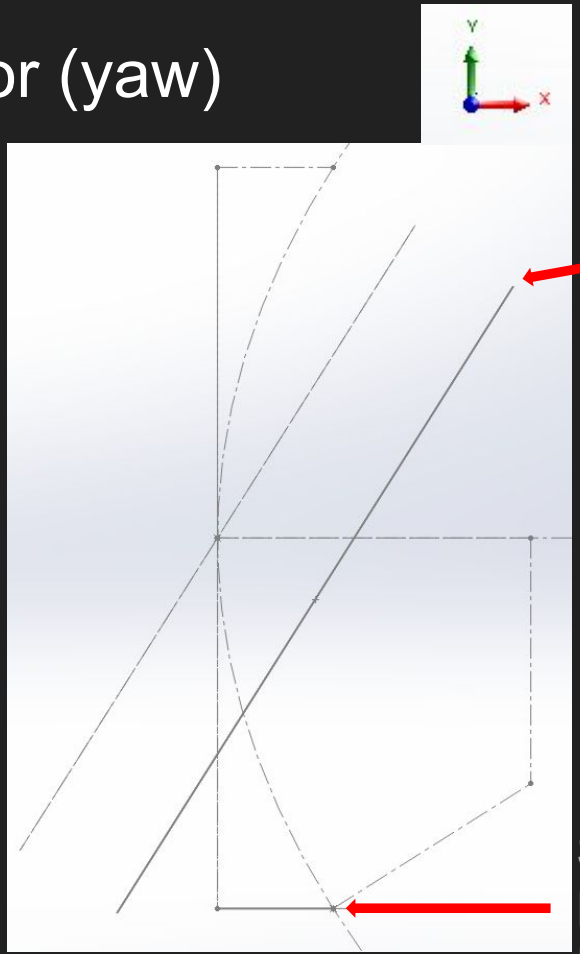
- However must first decenter in x,y,z

*Rotation arbitrary because it is in the z and can't be seen in this representation. Creates a circle (more on next slide)



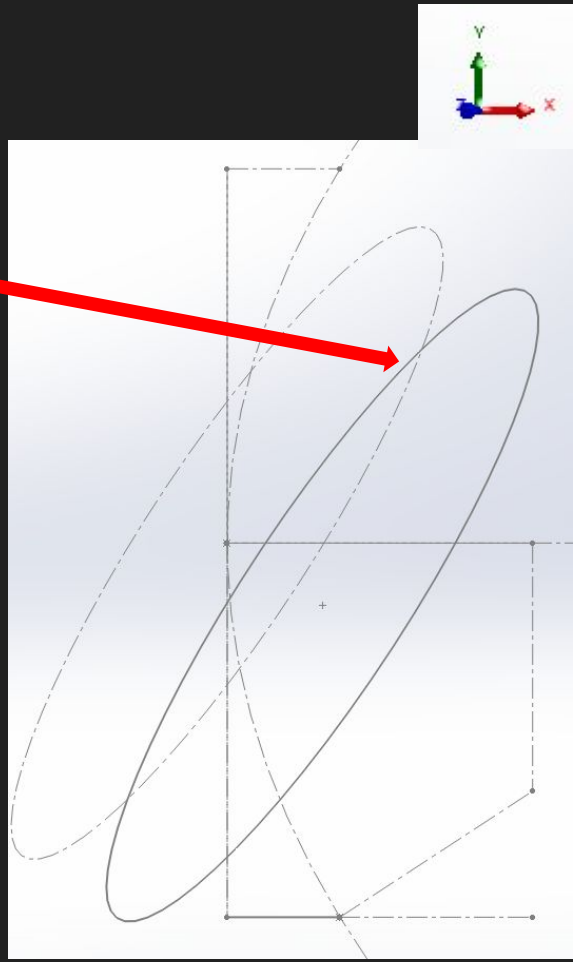
Clocking Error (yaw)





All possible locations of subaperture after tip & z rotation

Subaperture No z rot No tip



Be careful height dif of ~0.7

Use solidworks to find the attributes of the big triangle

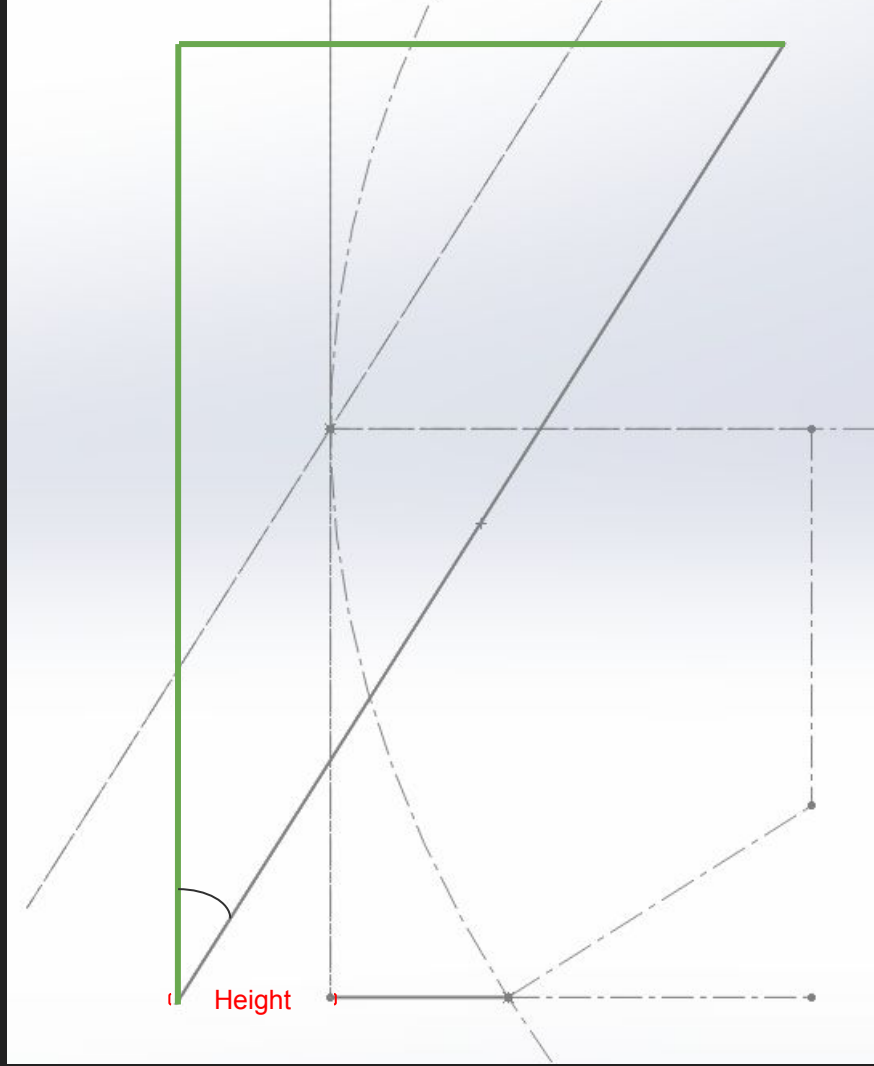
Then use angle of clocking to find point on circle where it intersects

Then use similar triangles to find dif in y and z

Use clocking angle and known radius of circle to find x difference

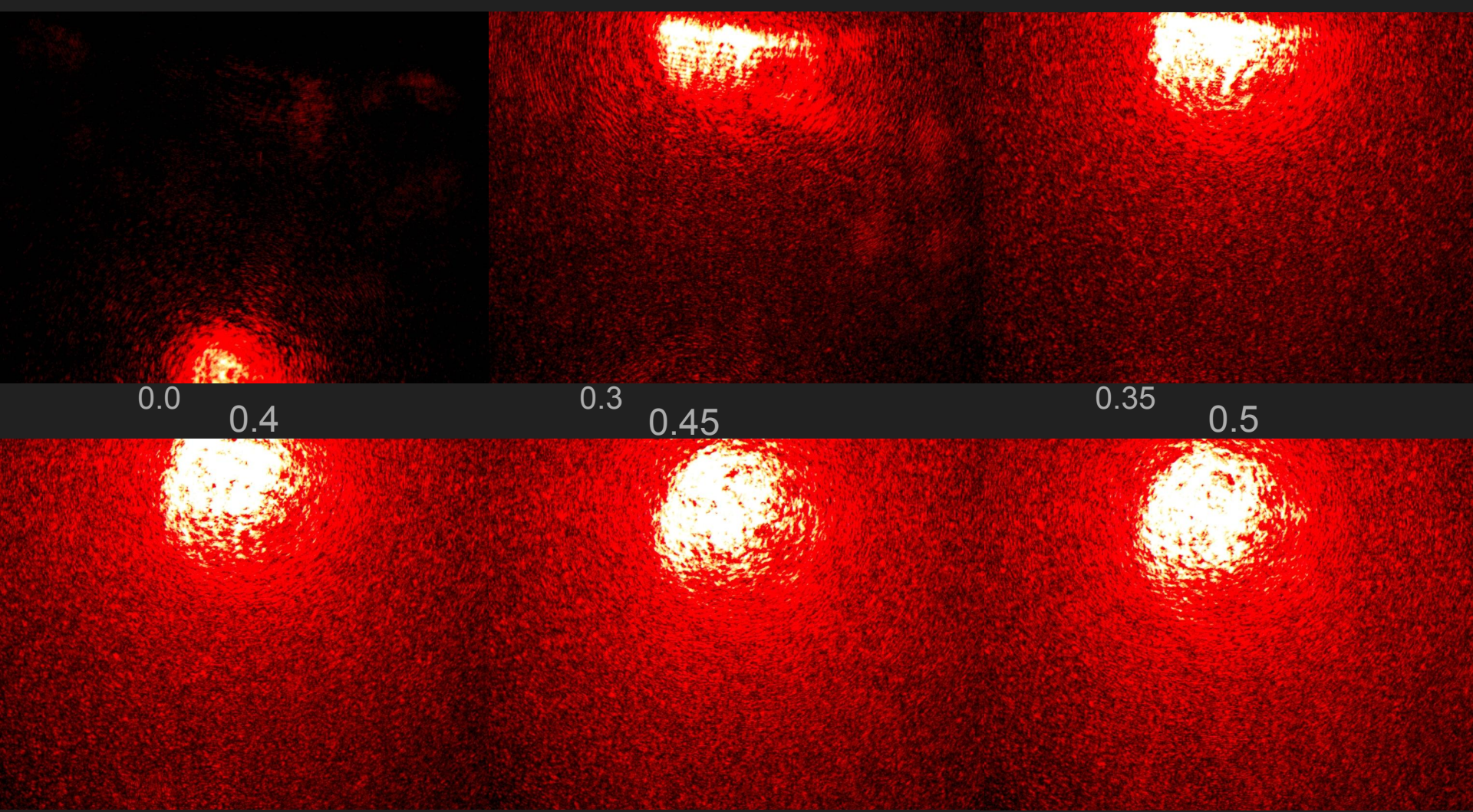
Decenter by x,y,z (plus height dif) then tip then clocking error

BOOM DONE!!!!



Fiber Experiment

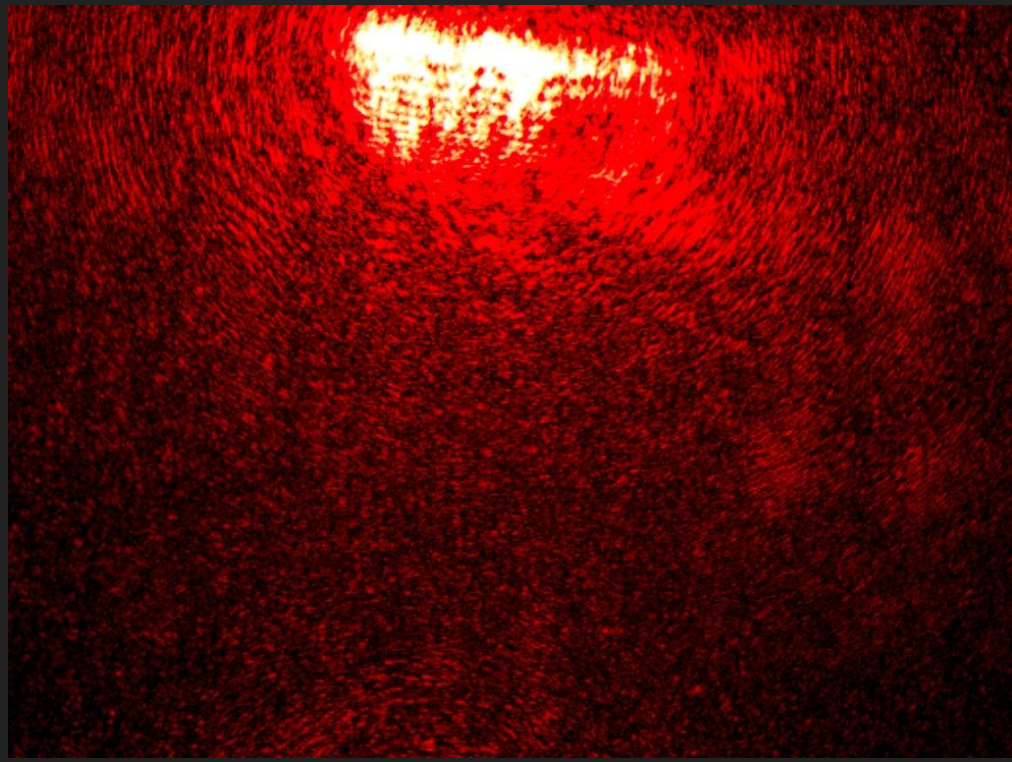
Declan


0.0
0.4
0.3
0.45
0.35
0.5

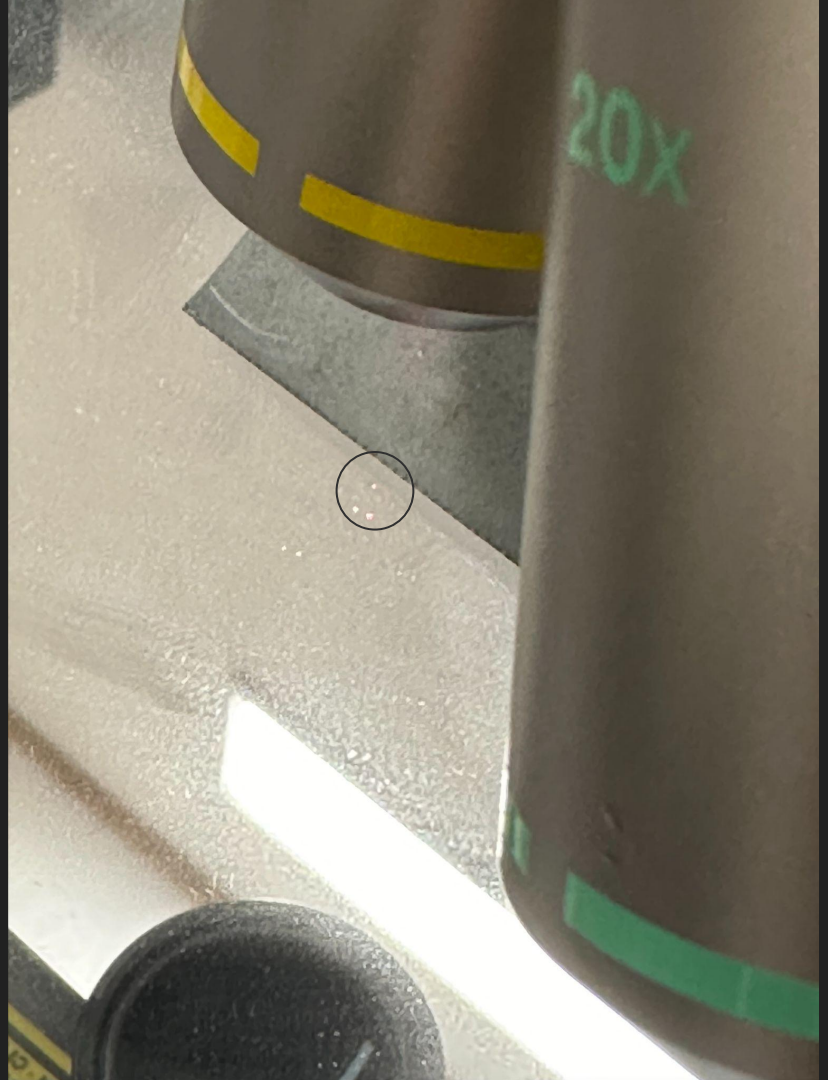
600 micron

- 0 to 30 on the thimble

Seems wrong




10x
20x


20x

1.1875

Pounds

0.54 kg