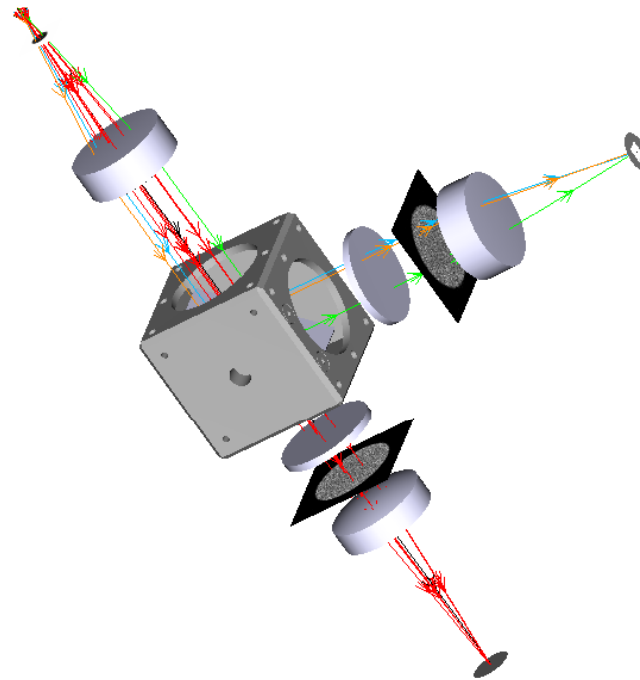


Analysis of Beam Splitter Assembly

using the ZEMAX Optical Design Program

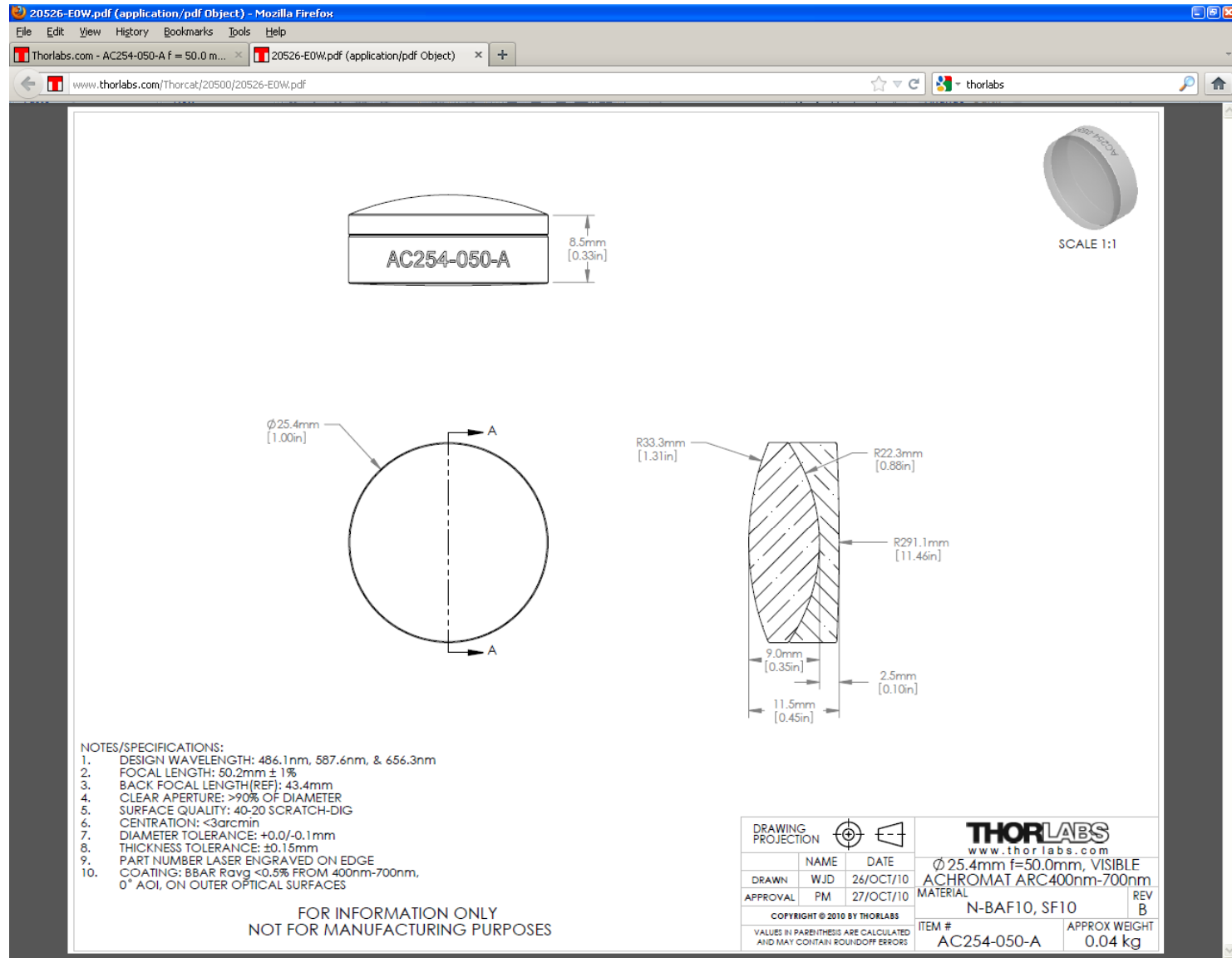
C. Zarobila 3/29/2012



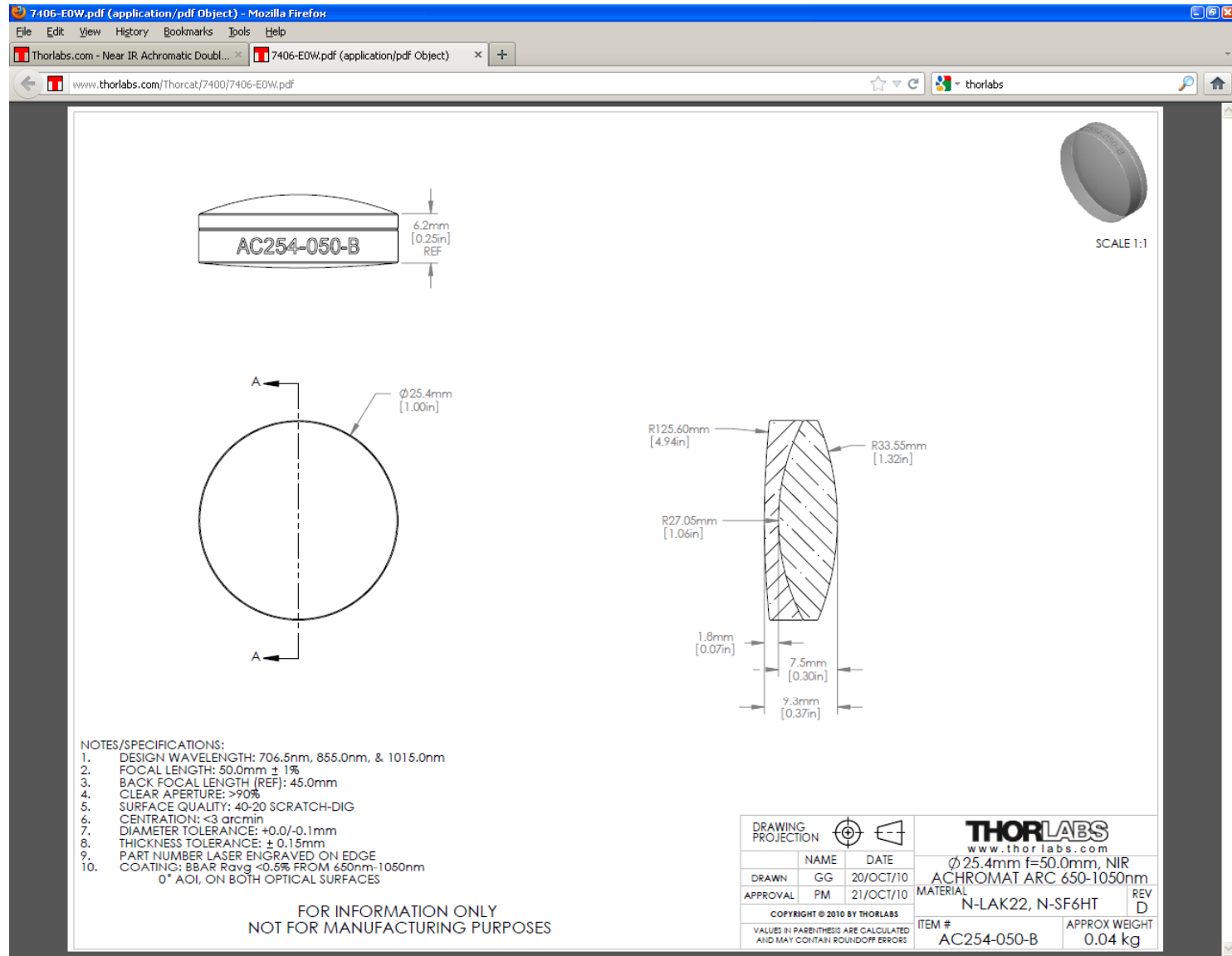
Optical Parts List

- Input fiber: 600 μm core, NA = 0.22
- Output fibers: 600 μm core, NA = 0.22
- Input (collimating) lens: ThorLabs AC254-050-A achromat, diam. = 25.4 mm, t = 11.5 mm, f = 50 mm, glass types SF10 and N-BAF10, AR coated for visible (400 to 700 nm)
- “Red” channel output lens: Thorlabs AC254-050-B achromat, diam. = 25.4 mm, t = 9.3 mm, f = 50 mm, glass types N-LAK22 and N-SF6HT, AR coated for IR (650 to 1050 nm)
- “Blue” channel output lens: same as input lens
- Dichroic beam splitter: SEMROCK FF605-Di02, 25.2 mm x 35.6 mm, t = 1.05 mm, substrate = ? (fused silica assumed), 45 deg +/- 1.5 deg AOI, orient reflective surface towards incoming light
- Various filters (KG3, GG495, others) potentially in path

AC254-050-A

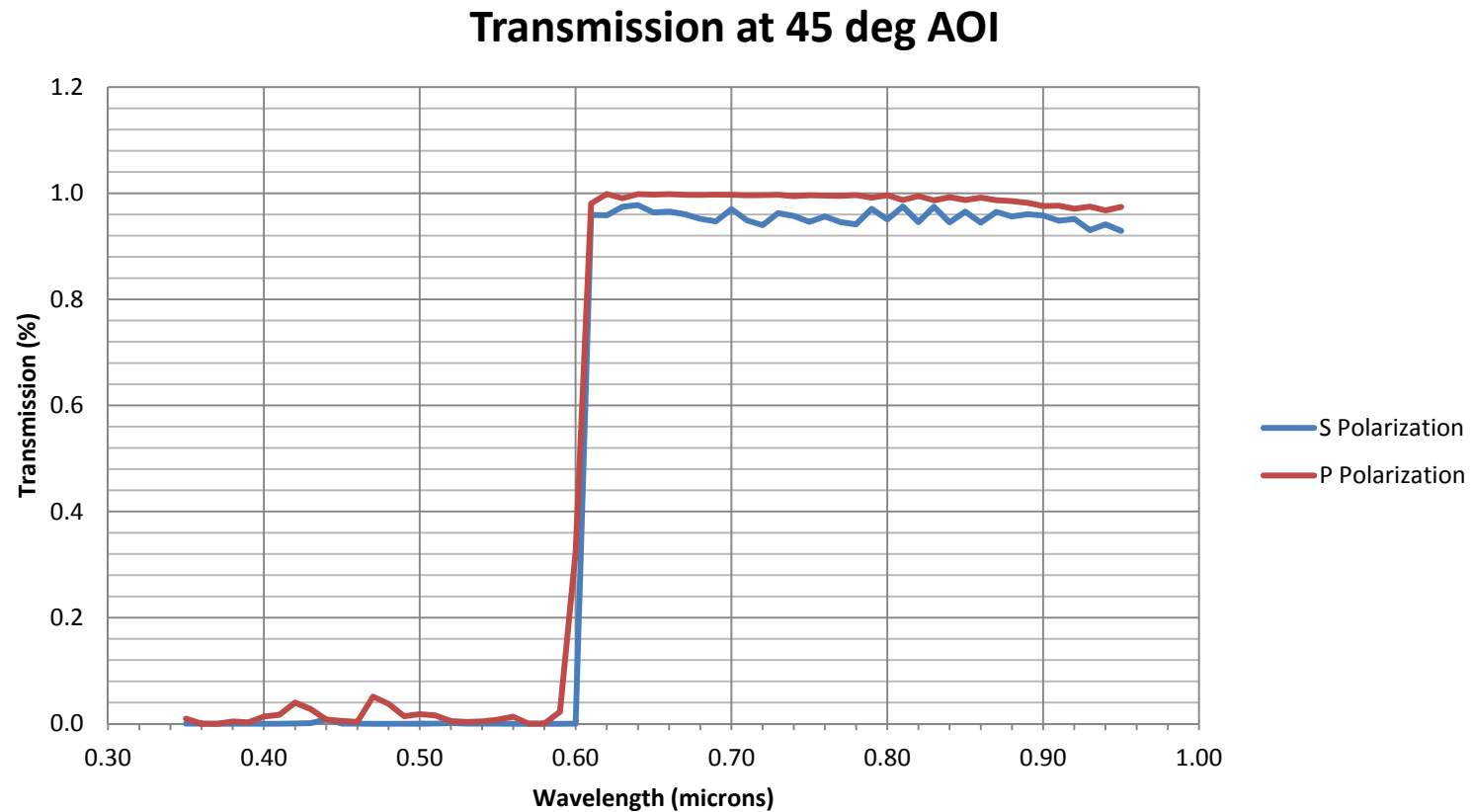


AC254-050-B



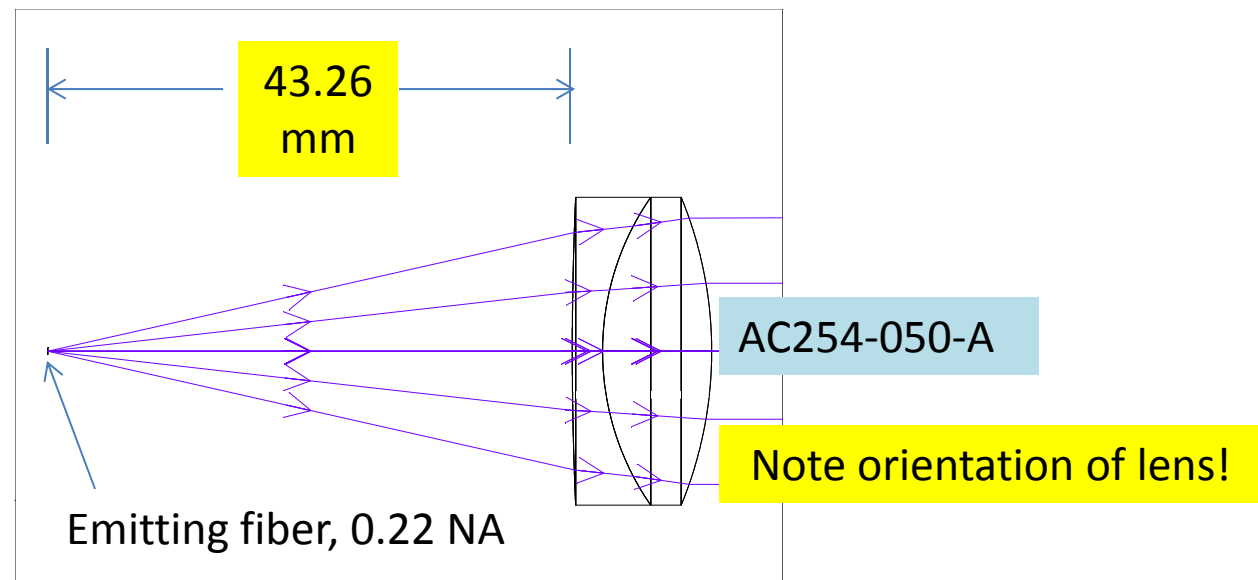
SEMROCK FF605-DiO2- 25x36

(10 nm data culled from website)

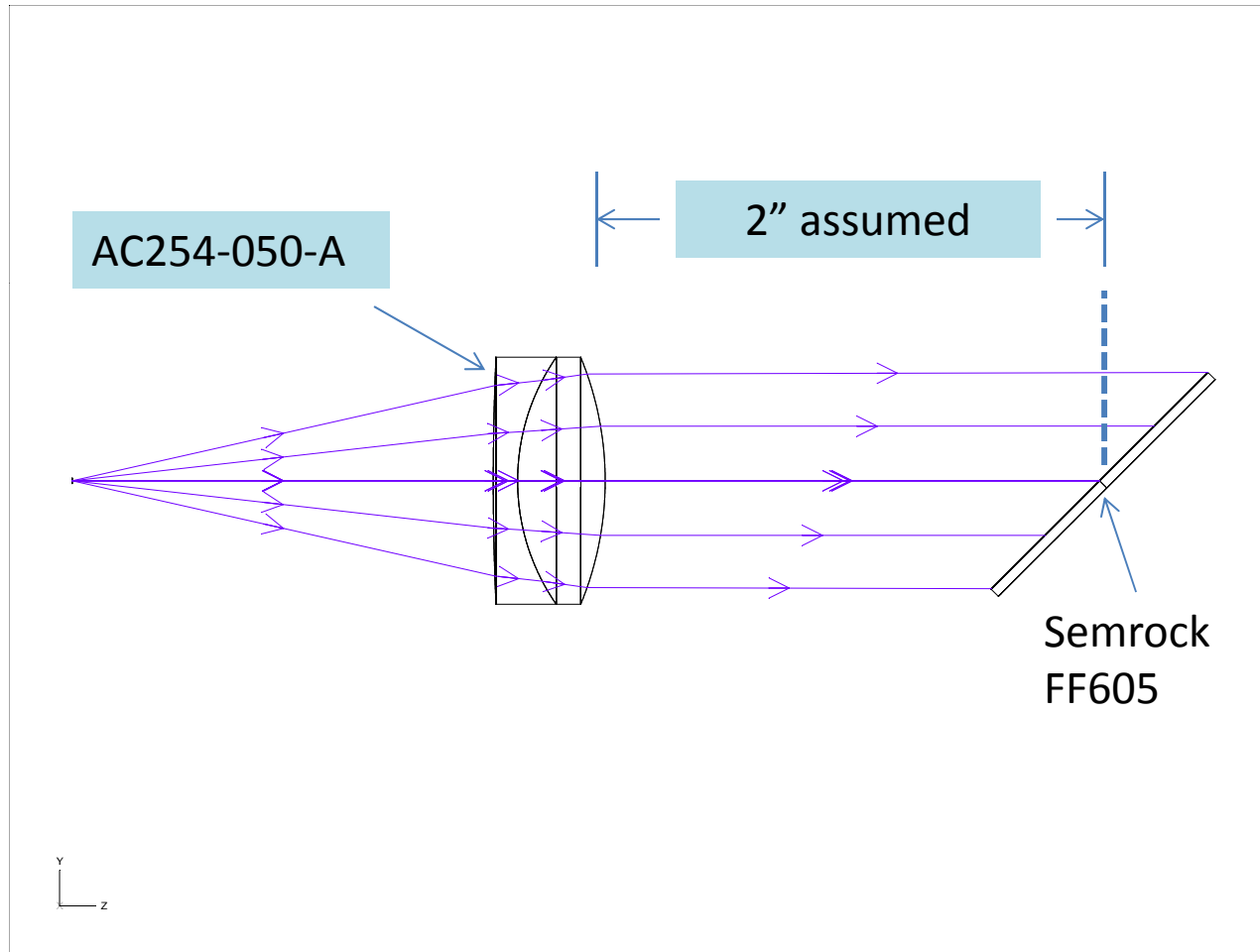


Use ZEMAX to calculate...

- Optimum axial location of emitting fiber w.r.t. AC254-050-A 1st surface for least angular spread of beam (and thus best collimation):

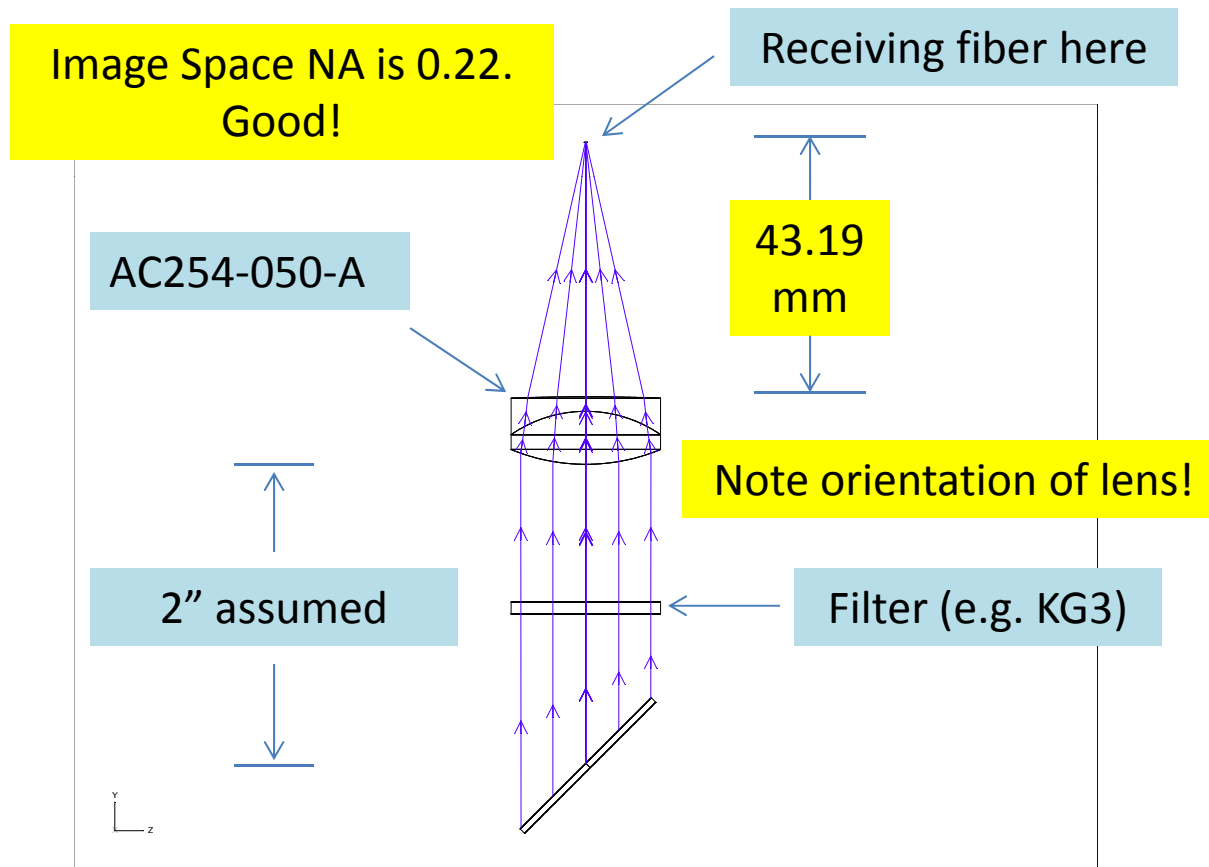


Use ZEMAX to orient beam-splitter...

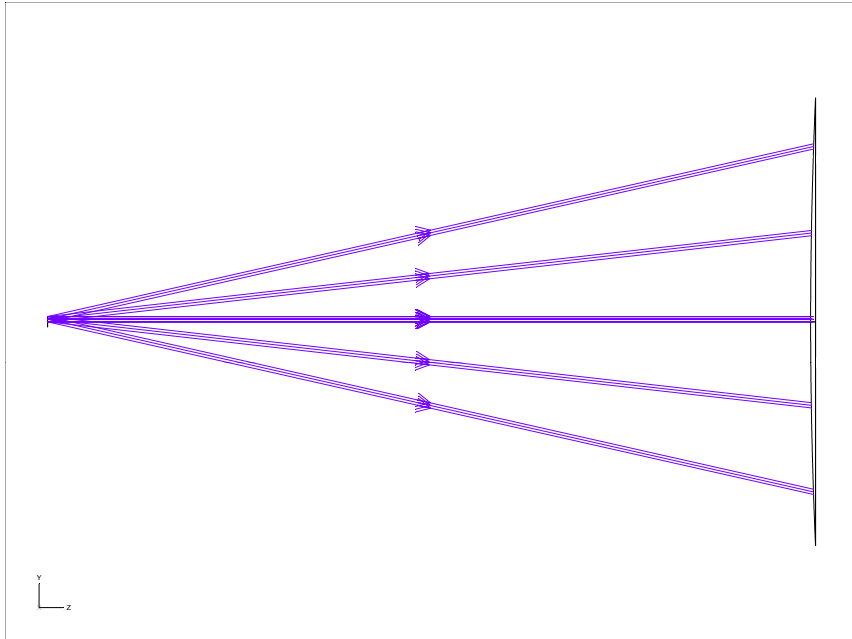


Use ZEMAX to calculate...

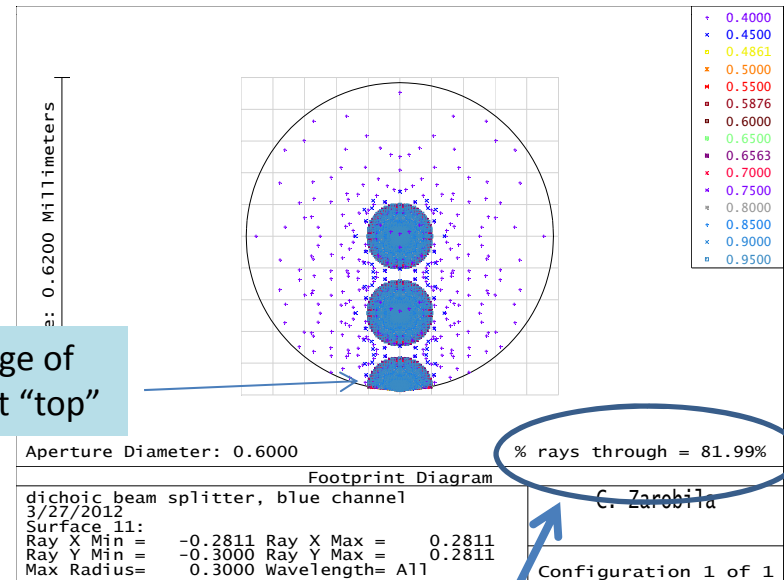
- Distance of receiving fiber from 2nd surface of output lens (blue channel) for smallest RMS spot size:



Blue Channel: Footprint of image, and vignetting



- The emitting fiber is actually an object that has finite extent (300 micron height)
- Points that emit light do not image as points due to non-ideal lenses (aberrations)



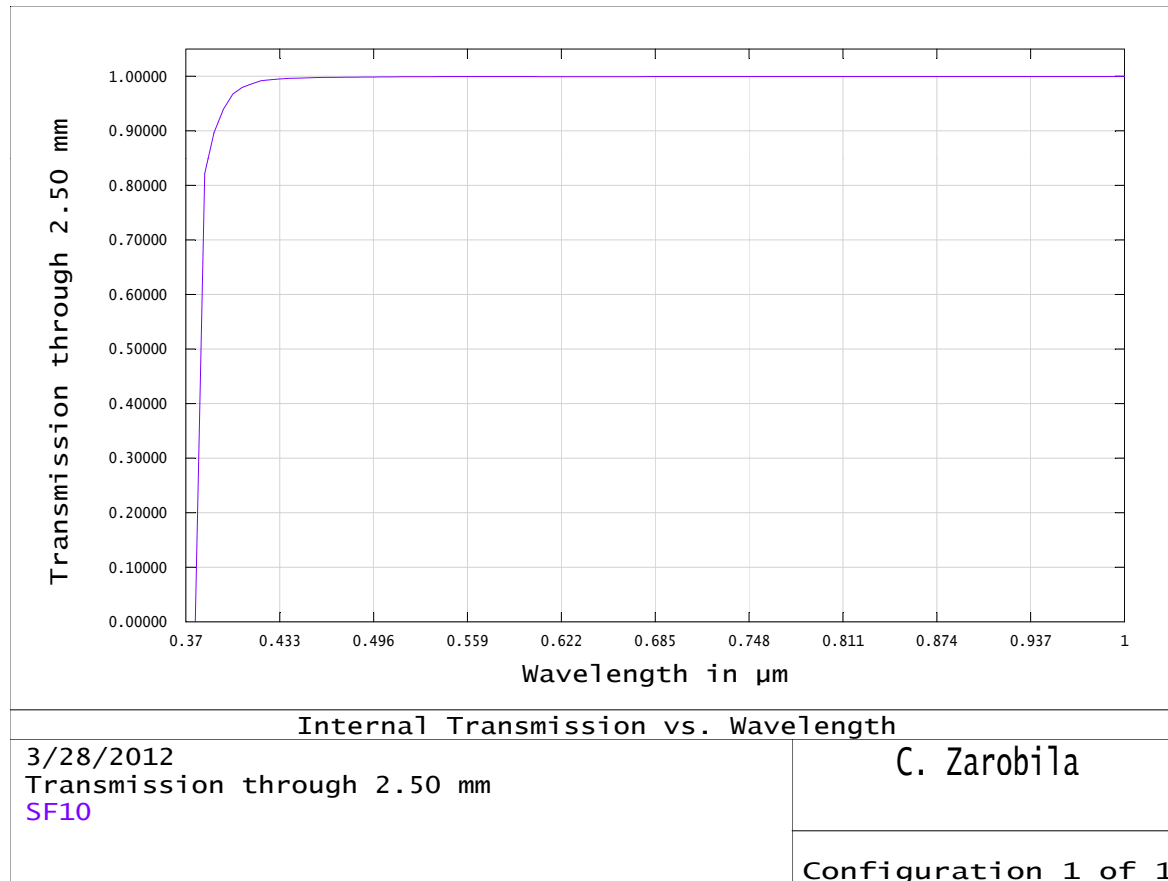
This is a pretty good result, though, for a COTS lens(es). So, it is a good choice!

However...

Approximately 18% of the light striking the plane is lost due to vignetting of rays by the receiving fiber core

If 370 nm is eventually desired...

- Must redesign and replace AC254-050-A since glass type SF10 cuts off at about 380 nm and is unusable at $\lambda < 380$ nm; keep this in mind



Calculated Transmission through blue optics for unpolarized light, simple AR coat for lenses assumed

Field Pos : 0.0000, 0.0000 mm

Transmission at	0.4000:	0.598996133
Transmission at	0.4500:	0.740254312
Transmission at	0.4861:	0.763275534
Transmission at	0.5000:	0.774629514
Transmission at	0.5500:	0.799025020
Transmission at	0.5876:	0.799603974
Transmission at	0.6000:	0.662456118
Transmission at	0.6500:	0.014355223
Transmission at	0.6563:	0.013625706
Transmission at	0.7000:	0.012199848
Transmission at	0.7500:	0.021311426
Transmission at	0.8000:	0.019653335
Transmission at	0.8500:	0.018132759
Transmission at	0.9000:	0.025463131
Transmission at	0.9500:	0.036574286
Total Transmission	:	0.353303755

Field Pos : 0.0000, 0.1500 mm

Transmission at	0.4000:	0.559021190
Transmission at	0.4500:	0.740703298
Transmission at	0.4861:	0.763710235
Transmission at	0.5000:	0.775054831
Transmission at	0.5500:	0.799415655
Transmission at	0.5876:	0.799971556
Transmission at	0.6000:	0.662880375
Transmission at	0.6500:	0.014373746
Transmission at	0.6563:	0.013643534
Transmission at	0.7000:	0.012213811
Transmission at	0.7500:	0.021334660
Transmission at	0.8000:	0.019672763
Transmission at	0.8500:	0.018143965
Transmission at	0.9000:	0.025474512
Transmission at	0.9500:	0.036593627
Total Transmission	:	0.35081385

Field Pos : 0.0000, 0.3000 mm

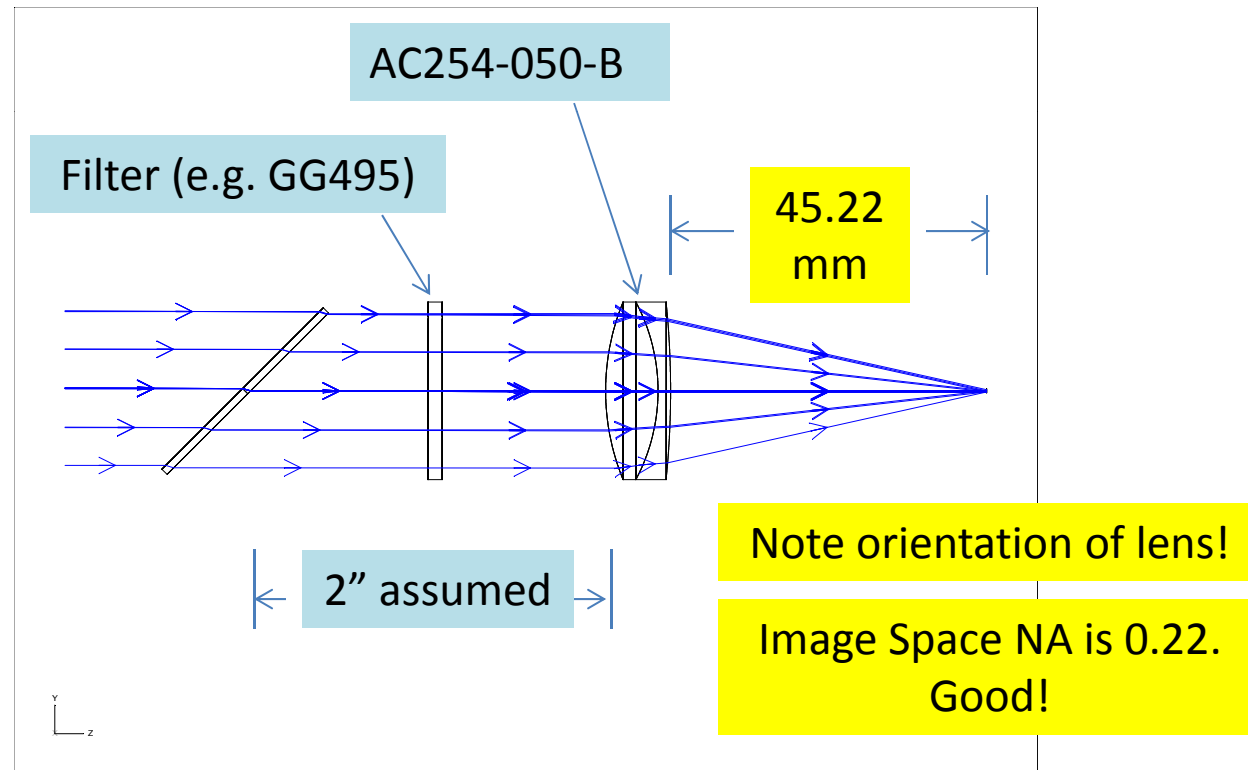
Transmission at	0.4000:	0.270975304
Transmission at	0.4500:	0.347797678
Transmission at	0.4861:	0.366276371
Transmission at	0.5000:	0.371702174
Transmission at	0.5500:	0.377315570
Transmission at	0.5876:	0.377563472
Transmission at	0.6000:	0.312903686
Transmission at	0.6500:	0.006806214
Transmission at	0.6563:	0.006443378
Transmission at	0.7000:	0.005828641
Transmission at	0.7500:	0.010126860
Transmission at	0.8000:	0.009534642
Transmission at	0.8500:	0.008745866
Transmission at	0.9000:	0.012214022
Transmission at	0.9500:	0.017545774
Total Transmission	:	0.166785310

Note the action of the DBS and how the vignetting affects T; and...may want that KG3 after all

Have not assumed any absorption or scattering in SEMROCK or lenses, so, these may be a bit high

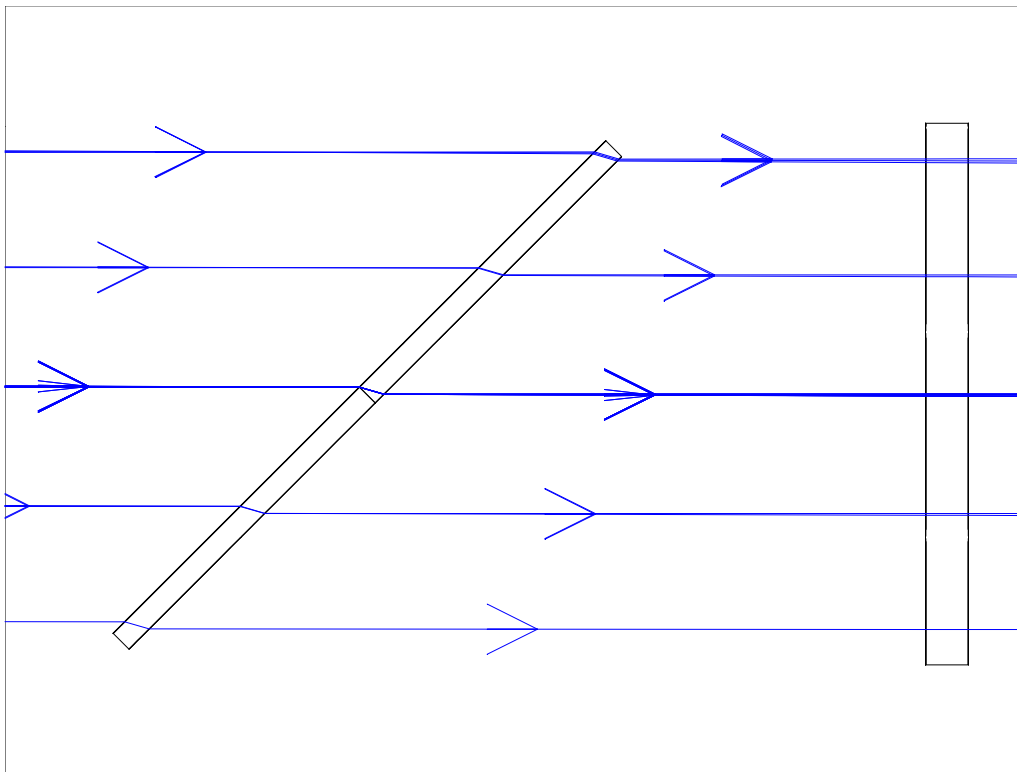
Red Channel: Use ZEMAX to calculate...

- Distance of receiving fiber from back surface of output lens (AC254-050-B) for smallest RMS spot size:



Effect of lateral offset

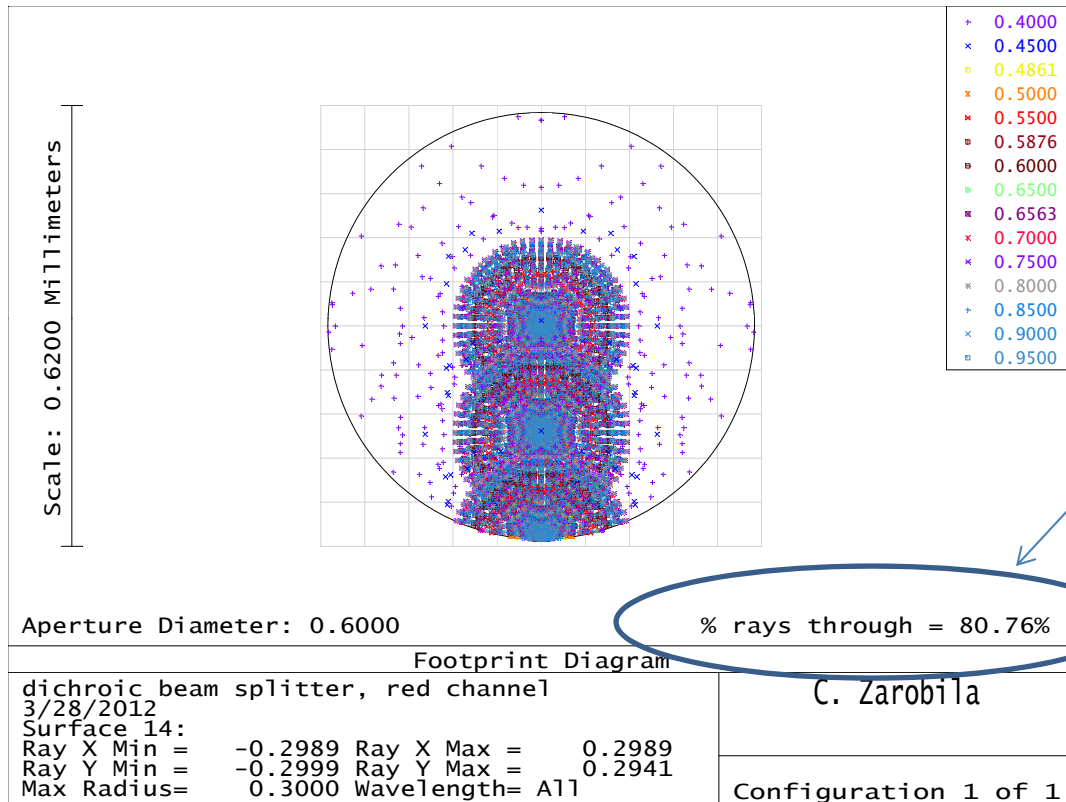
- Note the lateral offset introduced by DBS



Although the chief ray is shifted almost 600 microns, and parallel rays are shifted about 300 microns, by the time the rays are imaged, the effect is minimal (assuming no other tilts or decenters!)

➡ Ignore

Red Channel: Footprint of image, and vignetting



- Again, rays are clipped by the 600 micron receiving fiber core
- Of the light striking the image plane, roughly 20% is lost

Still, once again, this is a pretty good result for a COTS lens. So, the AC254-050-B is a good choice!

NO IR glass transmission issues here. But some of this light can be recovered by a custom design to improve the imaging

Calculated Transmission through red optics for unpolarized light, simple AR coat for lenses assumed

Field Pos : 0.0000, 0.0000 mm

Transmission at	0.4000:	0.003373232
Transmission at	0.4500:	0.001920745
Transmission at	0.4861:	0.008895854
Transmission at	0.5000:	0.007158596
Transmission at	0.5500:	0.003267124
Transmission at	0.5876:	0.007517792
Transmission at	0.6000:	0.142092183
Transmission at	0.6500:	0.860505245
Transmission at	0.6563:	0.863064189
Transmission at	0.7000:	0.875143456
Transmission at	0.7500:	0.866097623
Transmission at	0.8000:	0.864556162
Transmission at	0.8500:	0.859953187
Transmission at	0.9000:	0.843143649
Transmission at	0.9500:	0.820796880
Total Transmission	:	0.468499061

Field Pos : 0.0000, 0.1500 mm

Transmission at	0.4000:	0.003115375
Transmission at	0.4500:	0.001913112
Transmission at	0.4861:	0.008894952
Transmission at	0.5000:	0.007157941
Transmission at	0.5500:	0.003266866
Transmission at	0.5876:	0.007517199
Transmission at	0.6000:	0.142081152
Transmission at	0.6500:	0.860629559
Transmission at	0.6563:	0.863189723
Transmission at	0.7000:	0.875276481
Transmission at	0.7500:	0.866231824
Transmission at	0.8000:	0.864694742
Transmission at	0.8500:	0.860097073
Transmission at	0.9000:	0.843287871
Transmission at	0.9500:	0.820936172
Total Transmission	:	0.468552670

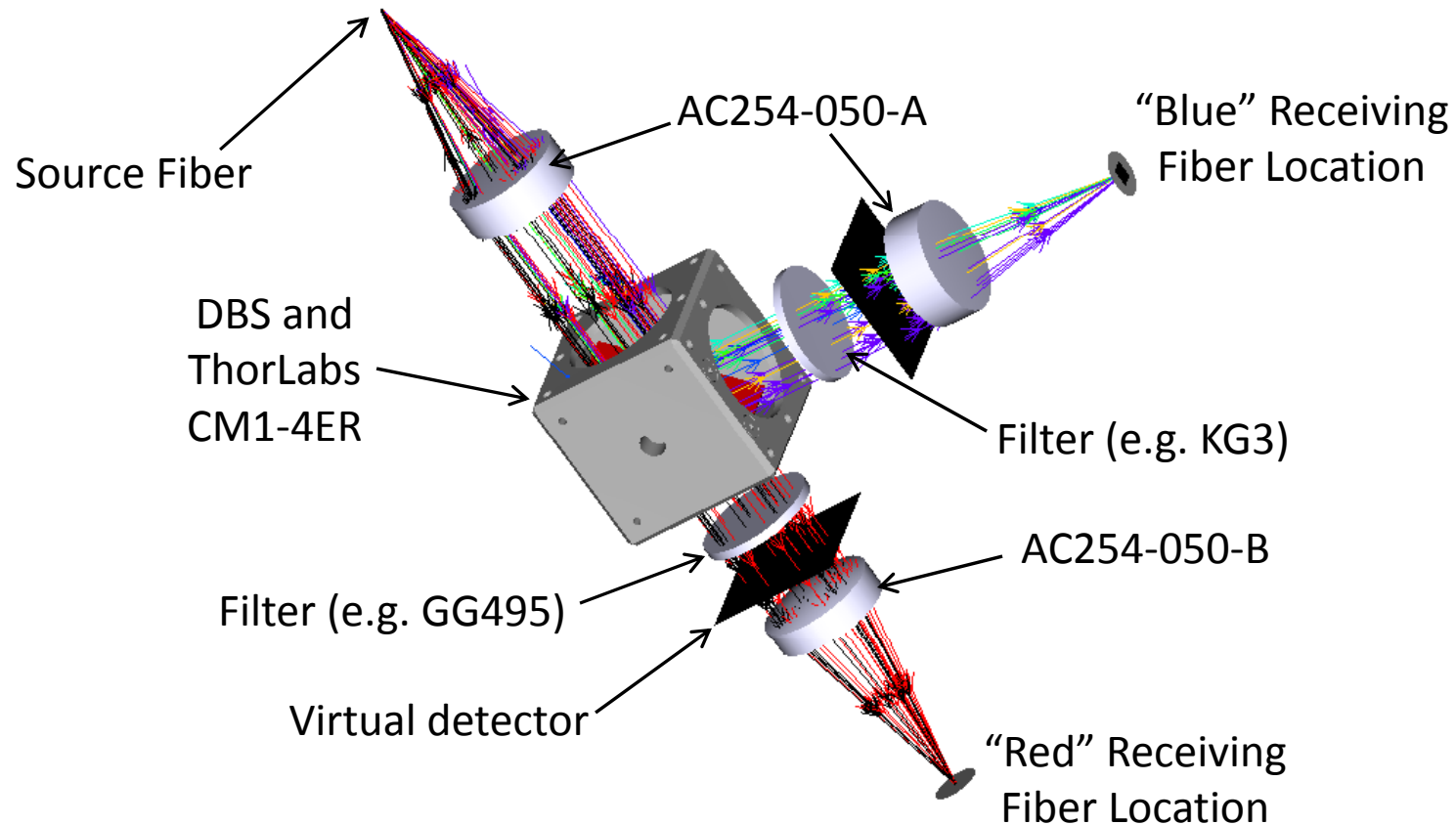
Field Pos : 0.0000, 0.3000 mm

Transmission at	0.4000:	0.001588465
Transmission at	0.4500:	4.5120E-004
Transmission at	0.4861:	0.003631079
Transmission at	0.5000:	0.003108246
Transmission at	0.5500:	0.001501012
Transmission at	0.5876:	0.003500263
Transmission at	0.6000:	0.066155629
Transmission at	0.6500:	0.404950316
Transmission at	0.6563:	0.406156660
Transmission at	0.7000:	0.411866399
Transmission at	0.7500:	0.415239828
Transmission at	0.8000:	0.426469592
Transmission at	0.8500:	0.443677154
Transmission at	0.9000:	0.441369274
Transmission at	0.9500:	0.422451960
Total Transmission	:	0.230141138

Note the action of the DBS and how the vignetting affects T; and...use GG495?

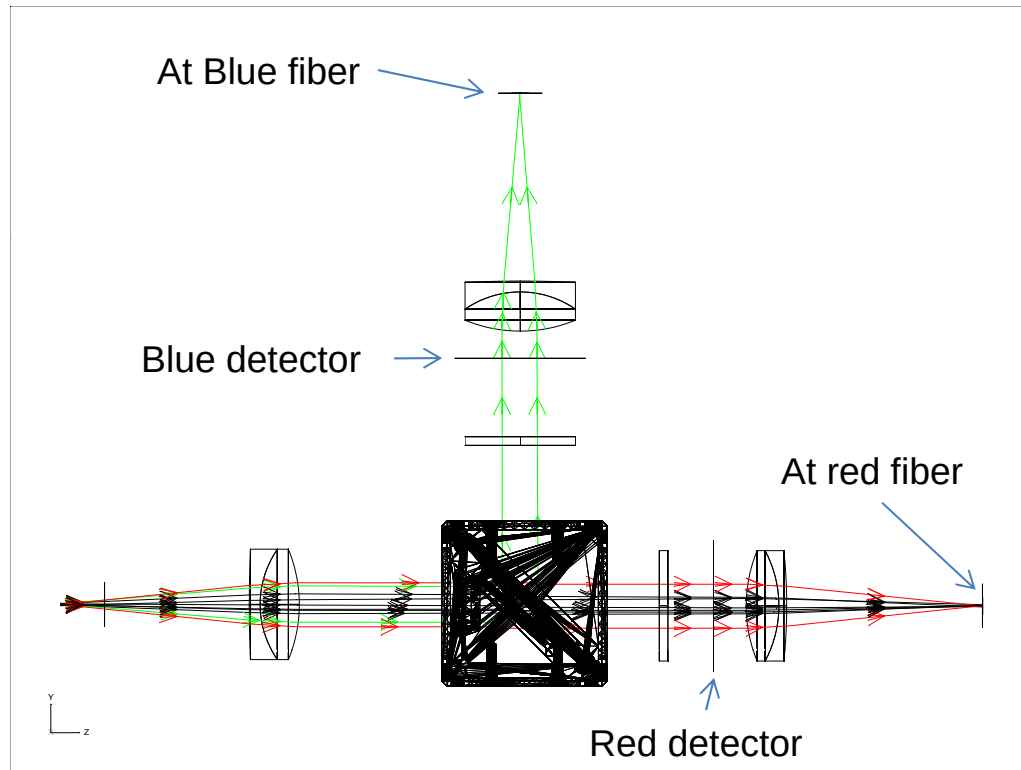
Put it all Together

Non-Sequential Raytrace

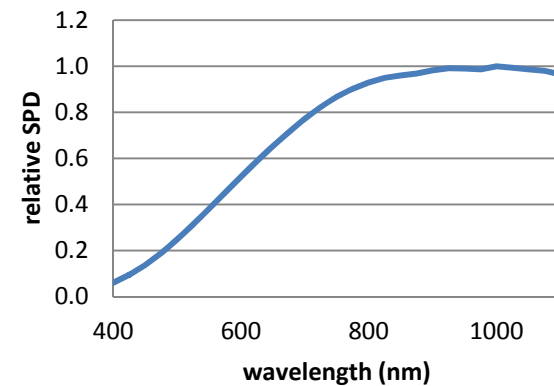


Estimate Throughput

(KG3, GG495 ignored for now)



NPR Source relative SPD



- Case 1: NPR Sphere Source

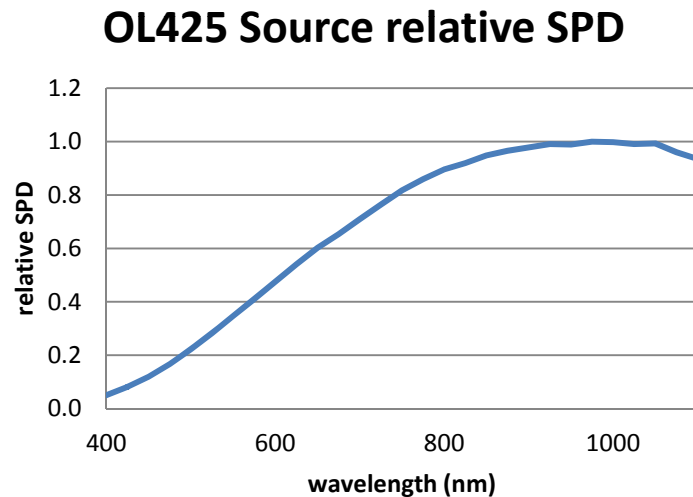
- Assume unity total power from 400 to 1100 nm

Fraction at blue detector: 0.15
Fraction at blue fiber: 0.12
Fraction at red detector: 0.76
Fraction at red fiber: 0.68

Estimate Throughput

(KG3, GG495 ignored for now)

- Case 2: OL425 Sphere Source
 - Assume unity total power from 400 to 1100 nm



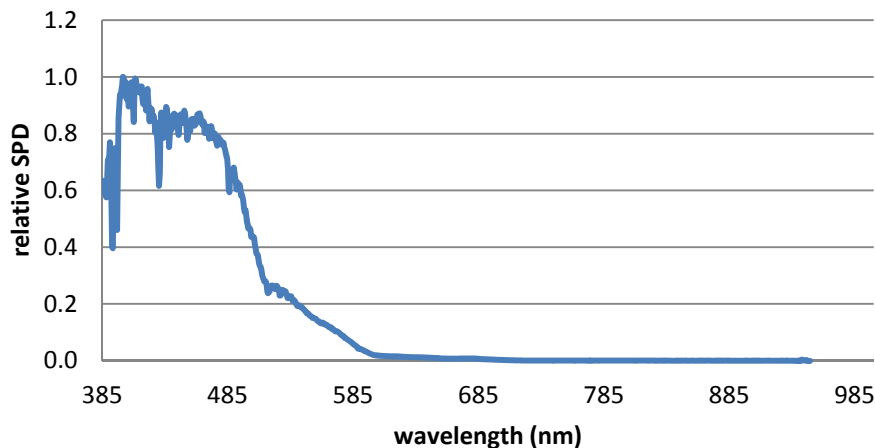
Fraction at blue detector: 0.14
Fraction at blue fiber: 0.12
Fraction at red detector: 0.77
Fraction at red fiber: 0.69

Estimate Throughput

(KG3, GG495 ignored for now)

- Case 3: MOBY 213 Lu Top
 - Assume unity total power from 385 to 830 nm

MOBY213 Lu Top Source relative SPD



Fraction at blue detector: 0.81
Fraction at blue fiber: 0.65
Fraction at red detector: 0.02
Fraction at red fiber: 0.01

Estimate Throughput

(KG3, GG495 ignored for now)

- Imaginary Source, unity SPD
 - Assume unity total power from 400 to 950 nm

Fraction at blue detector: 0.42

Fraction at blue fiber: 0.35

Fraction at red detector: 0.48

Fraction at red fiber: 0.42