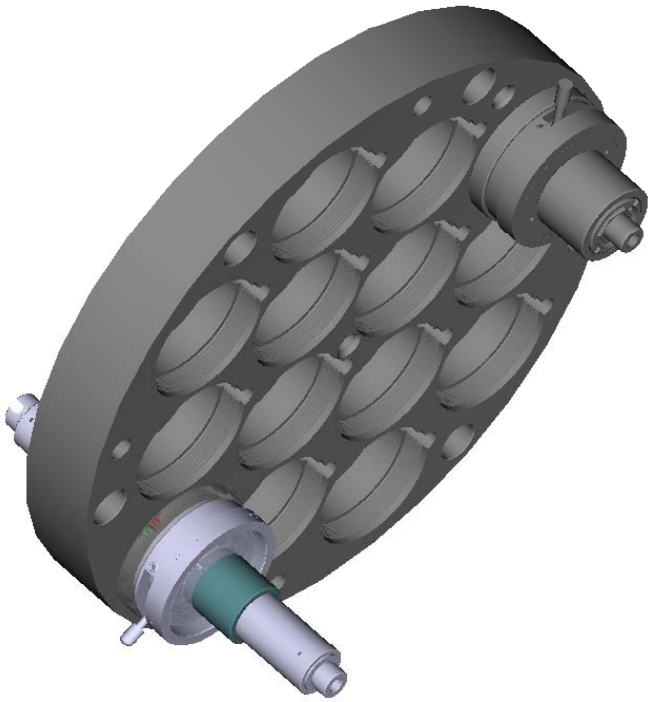
Analysis of shutter/collimator assembly

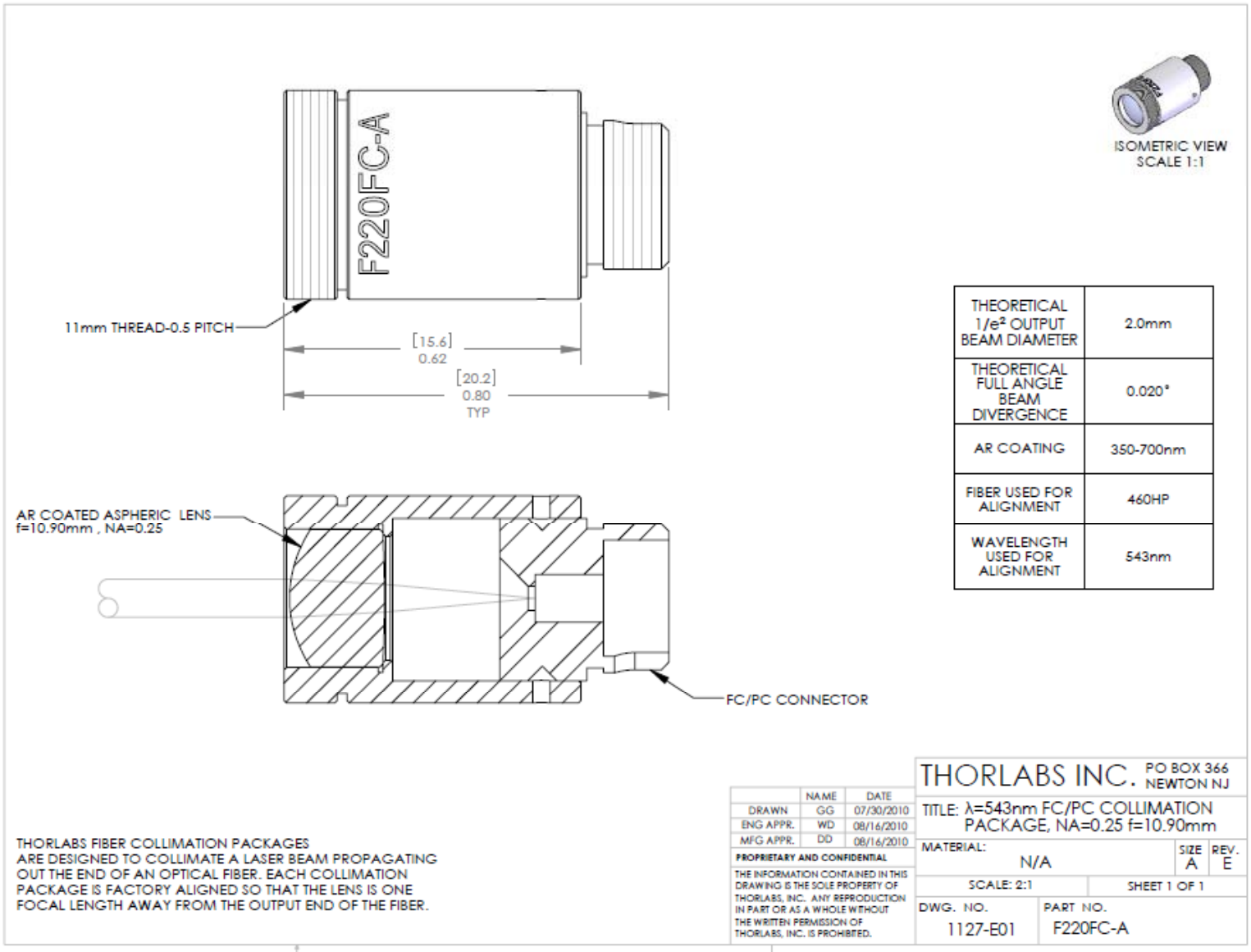
C. Zarobila 4-03-2012_4-06-2012



Parts List:Blue

- ThorLabs: F220FC-A, F260 SMA-A, AD1109F (2 per coupling), SM1D12 (or SM1D12SZ), SM1A6, SM1A1
- Shutter Assembly (MLML)
- Shutter and Shutter Retainer (MLML)

F220FC-A Housing



THEORETICAL $1/e^2$ OUTPUT BEAM DIAMETER	2.0mm
THEORETICAL FULL ANGLE BEAM DIVERGENCE	0.020°
AR COATING	350-700nm
FIBER USED FOR ALIGNMENT	460HP
WAVELENGTH USED FOR ALIGNMENT	543nm

THORLABS FIBER COLLIMATION PACKAGES
ARE DESIGNED TO COLLIMATE A LASER BEAM PROPAGATING OUT THE END OF AN OPTICAL FIBER. EACH COLLIMATION PACKAGE IS FACTORY ALIGNED SO THAT THE LENS IS ONE FOCAL LENGTH AWAY FROM THE OUTPUT END OF THE FIBER.

	NAME	DATE
DRAWN	GG	07/30/2010
ENG APPR.	WD	08/16/2010
MFG APPR.	DD	08/16/2010

THORLABS INC. PO BOX 366 NEWTON NJ

TITLE: λ=543nm FC/PC COLLIMATION PACKAGE, NA=0.25 f=10.90mm

MATERIAL:	SIZE	REV.
N/A	A	E

SCALE: 2:1 SHEET 1 OF 1

DWG. NO.	PART NO.
1127-E01	F220FC-A

5 4 3 2 1

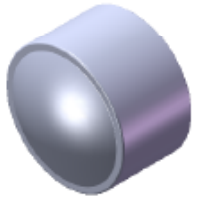
F220FC-A aspheric lens, best-guess

ASPHERIC COEFFICIENTS

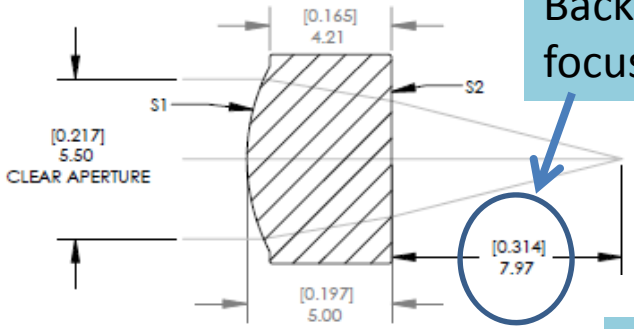
	R	k	A_2	A_4	A_6	A_8	A_{10}
S1	6.64	-0.5500112	-	2.6715670E-06	-4.1960626E-07	-	-
S2	PLANO	-	-	-	-	-	-

$$z = \frac{Y^2}{R\left(1+\sqrt{1-(1+k)Y^2/R^2}\right)} + A_2Y^2 + A_4Y^4 + A_6Y^6 + A_8Y^8 + A_{10}Y^{10}$$

ASPHERIC LENS EQUATION

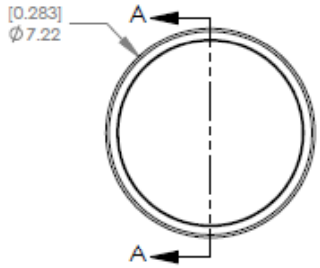


ISOMETRIC VIEW



SECTION A-A

Back focus



SPECIFICATIONS:
DESIGN WAVELENGTH: 633nm
EFFECTIVE FOCAL LENGTH: 11.00mm
EFL TOLERANCE: ±1%
NUMERICAL APERTURE: 0.25
WORKING DISTANCE: 7.97mm
DIAMETER TOLERANCE: ±0.015mm
CENTER THICKNESS TOLERANCE: ±0.04mm
SURFACE QUALITY: 40-20 SCRATCH-DIG (INCLUDES ENTIRE BULK MATERIAL)
RMS WFE: ≤ DIFFRACTION LIMITED
MAGNIFICATION: INFINITE
REFRACTIVE INDEX (AT DESIGN WAVELENGTH): 1.603
INDEX TOLERANCE: ±0.002
COATING(S1&S2): BBAR Ravg<0.5% FROM 400-600nm

NOTE molded glass type ECO-550, proprietary to Lightpath Technologies; SK16 substituted for ZEMAX to model

[in]
ALL DIMENSIONS ARE IN mm
THIS DRAWING IS FOR INFORMATION ONLY
NOT INTENDED FOR MANUFACTURING

	NAME	DATE
DRAWN	SFG	11/12/2009
ENG APPR.	DJ	12/05/2009
MFG APPR.	DD	12/17/2009

PROPRIETARY AND CONFIDENTIAL

THORLABS INC. PO BOX 366 NEWTON NJ

TITLE: A COATED ASPHERIC COLLIMATING LENS EFL=11.00mm

MATERIAL: ECO-550

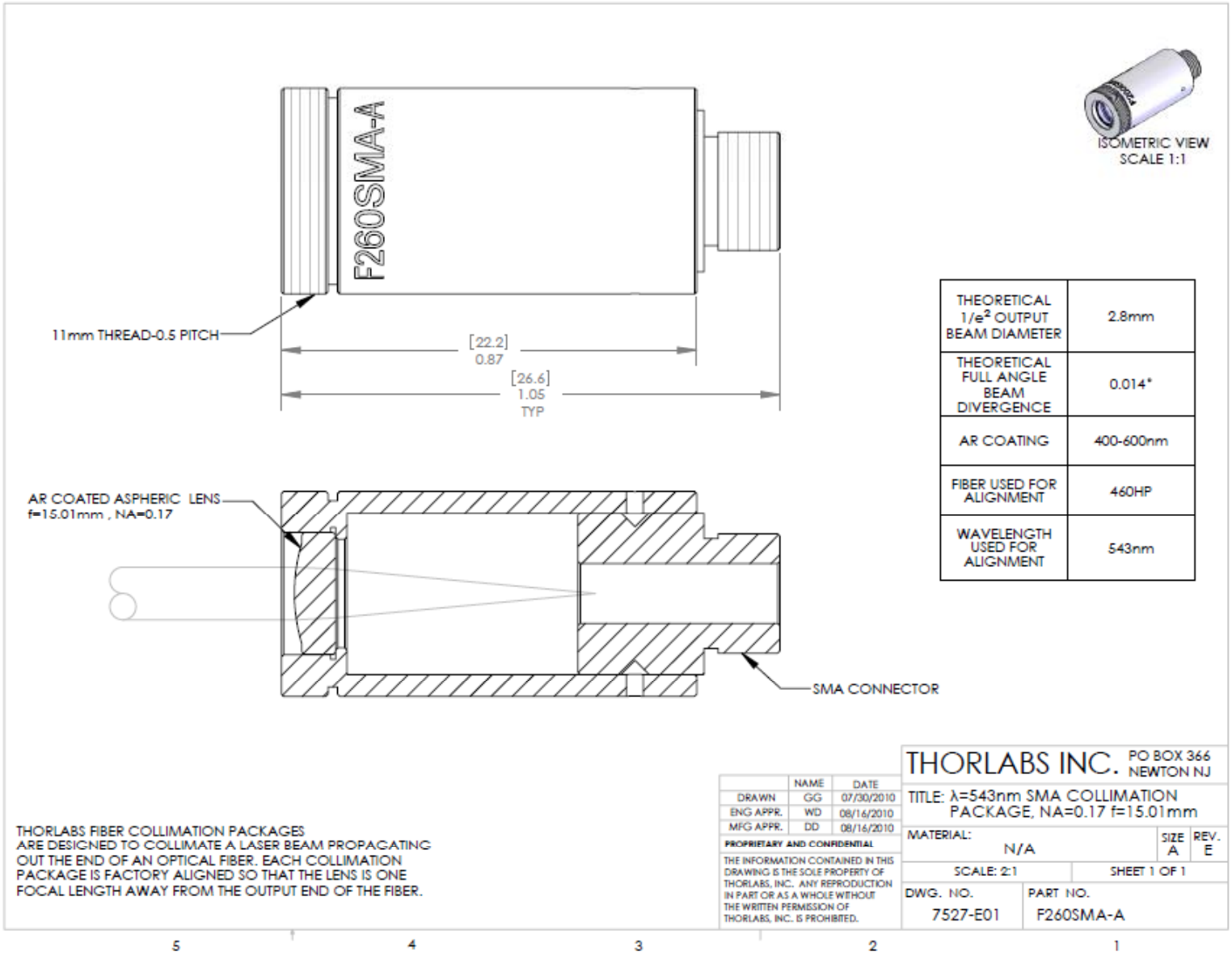
SIZE A | REV. C

SCALE: 5:1 | SHEET 1 OF 1

DWG. NO. 13709-E01 | PART NO. 352220-A

5 4 3 2 1

F260SMA-A Housing



THEORETICAL $1/e^2$ OUTPUT BEAM DIAMETER	2.8mm
THEORETICAL FULL ANGLE BEAM DIVERGENCE	0.014°
AR COATING	400-600nm
FIBER USED FOR ALIGNMENT	460HP
WAVELENGTH USED FOR ALIGNMENT	543nm

THORLABS FIBER COLLIMATION PACKAGES ARE DESIGNED TO COLLIMATE A LASER BEAM PROPAGATING OUT THE END OF AN OPTICAL FIBER. EACH COLLIMATION PACKAGE IS FACTORY ALIGNED SO THAT THE LENS IS ONE FOCAL LENGTH AWAY FROM THE OUTPUT END OF THE FIBER.

	NAME	DATE
DRAWN	GG	07/30/2010
ENG APPR.	WD	08/16/2010
MFG APPR.	DD	08/16/2010

THORLABS INC. PO BOX 366 NEWTON NJ

TITLE: λ=543nm SMA COLLIMATION PACKAGE, NA=0.17 f=15.01mm

MATERIAL:	SIZE	REV.
N/A	A	E

SCALE: 2:1 SHEET 1 OF 1

DWG. NO.	PART NO.
7527-E01	F260SMA-A

5 4 3 2 1

F260SMA-A aspheric lens, best-guess

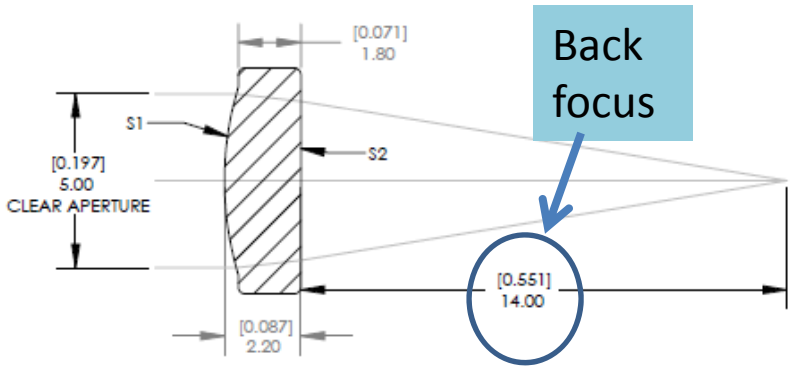
ASPHERIC COEFFICIENTS

	R	k	A_2	A_4	A_6	A_8	A_{10}
S1	9.14	-0.5378990	-	-8.0477102E-06	-1.2830678E-07	-	-
S2	PLANO	-	-	-	-	-	-

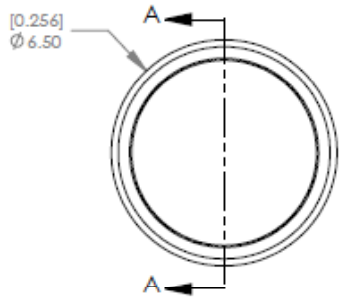
$$z = \frac{Y^2}{R(1+\sqrt{1-(1+k)Y^2/R^2})} + A_2Y^2 + A_4Y^4 + A_6Y^6 + A_8Y^8 + A_{10}Y^{10}$$

ASPHERIC LENS EQUATION

ISOMETRIC VIEW



SECTION A-A
SCALE 6 : 1



SPECIFICATIONS:

DESIGN WAVELENGTH: 780nm
EFFECTIVE FOCAL LENGTH: 15.29mm
EFL TOLERANCE: ±1%
NUMERICAL APERTURE: 0.16
WORKING DISTANCE: 14.00mm
DIAMETER TOLERANCE: ±0.015mm
CENTER THICKNESS TOLERANCE: ±0.04mm
SURFACE QUALITY: 40-20 SCRATCH-DIG (INCLUDES ENTIRE BULK MATERIAL)
RMS WFE: ≤ DIFFRACTION LIMITED
MAGNIFICATION: INFINITE
REFRACTIVE INDEX (AT DESIGN WAVELENGTH): 1.597
INDEX TOLERANCE: ±0.002
COATING(S1&S2): BBAR Ravg<0.5% FROM 400-600nm

[in]
ALL DIMENSIONS ARE IN mm
THIS DRAWING IS FOR INFORMATION ONLY
NOT INTENDED FOR MANUFACTURING

	NAME	DATE
DRAWN	SFG	11/13/2009
ENG APPR.	DJ	12/05/2009
MFG APPR.	DD	12/17/2009

PROPRIETARY AND CONFIDENTIAL

THORLABS INC. PO BOX 366 NEWTON NJ

TITLE: -A COATED ASPHERIC COLLIMATING LENS EFL=15.29mm

MATERIAL: ECO-550

SIZE A | REV. C

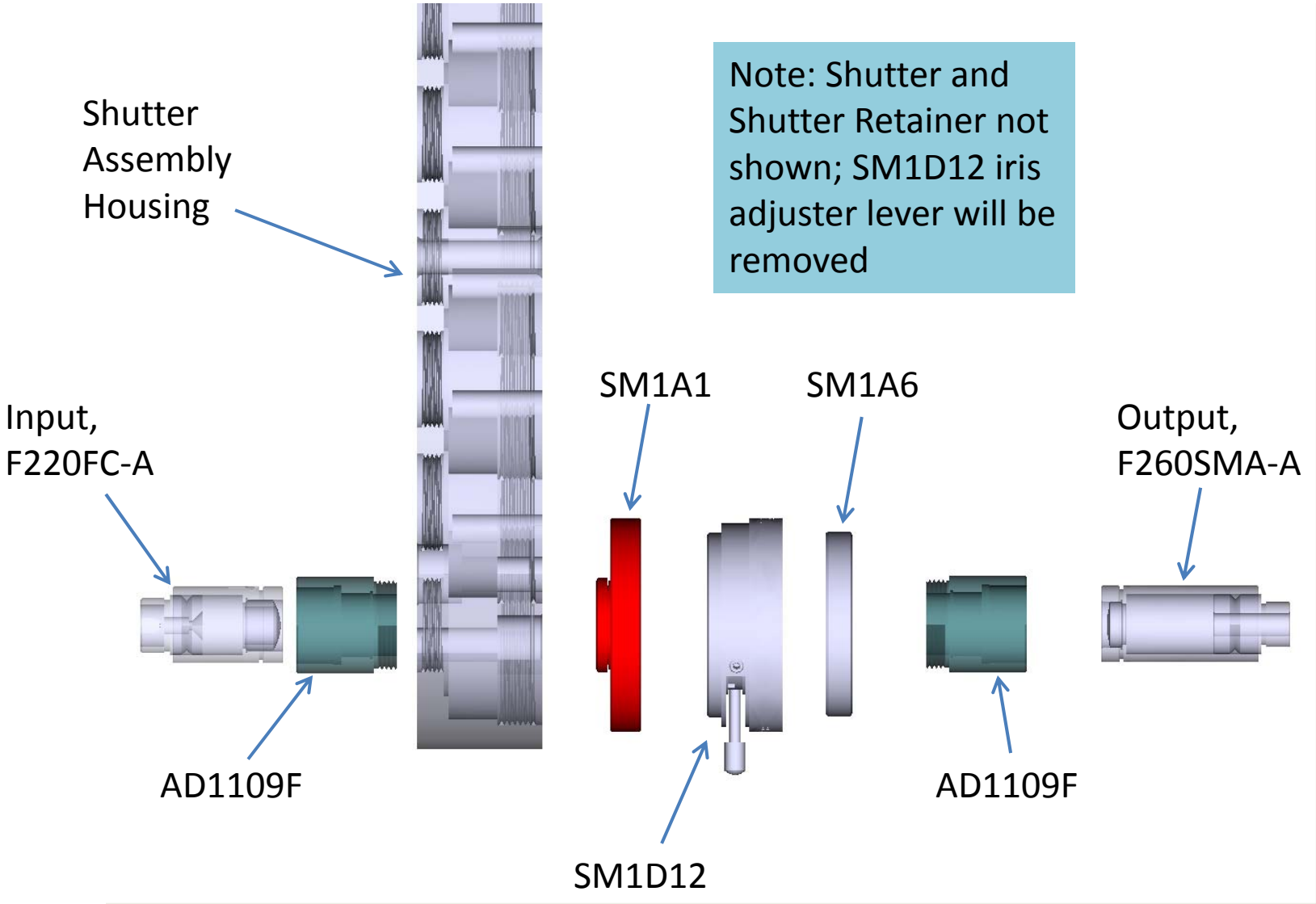
SCALE 6:1 | SHEET 1 OF 1

DWG. NO. 17798-E01

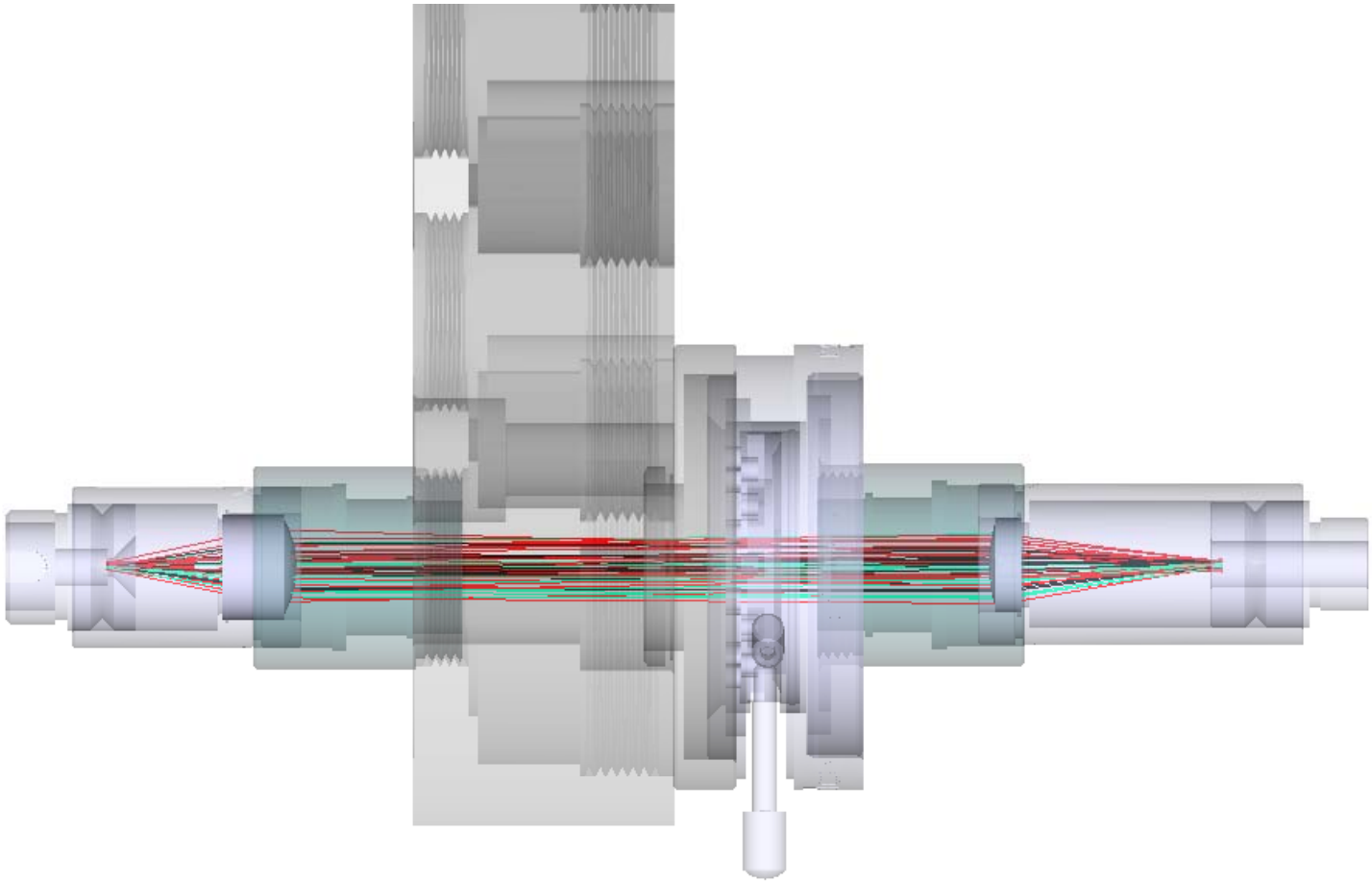
PART NO. 352260-A

5 4 3 2 1

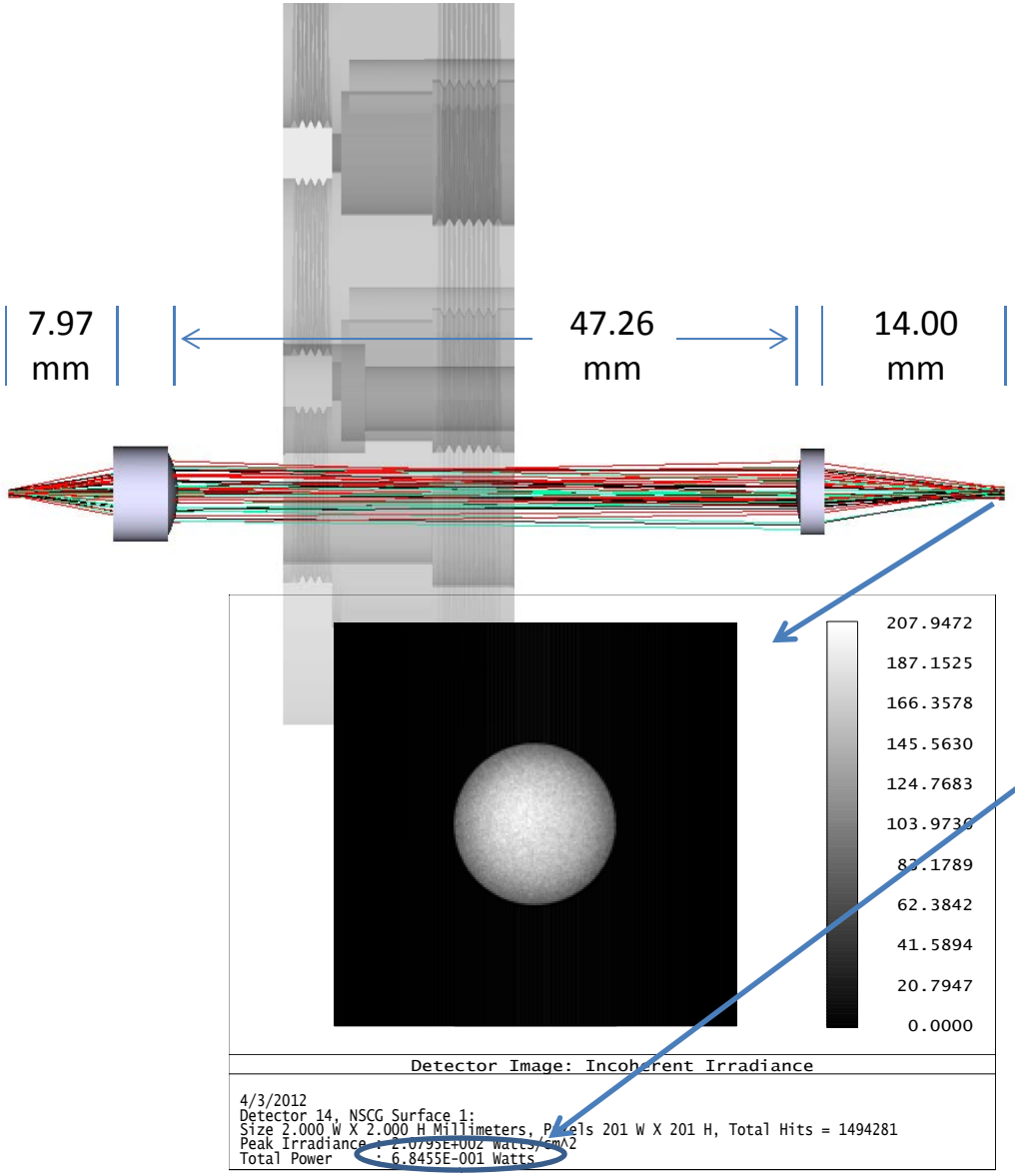
Exploded View, Blue



Assembled System and NonSequential Raytrace

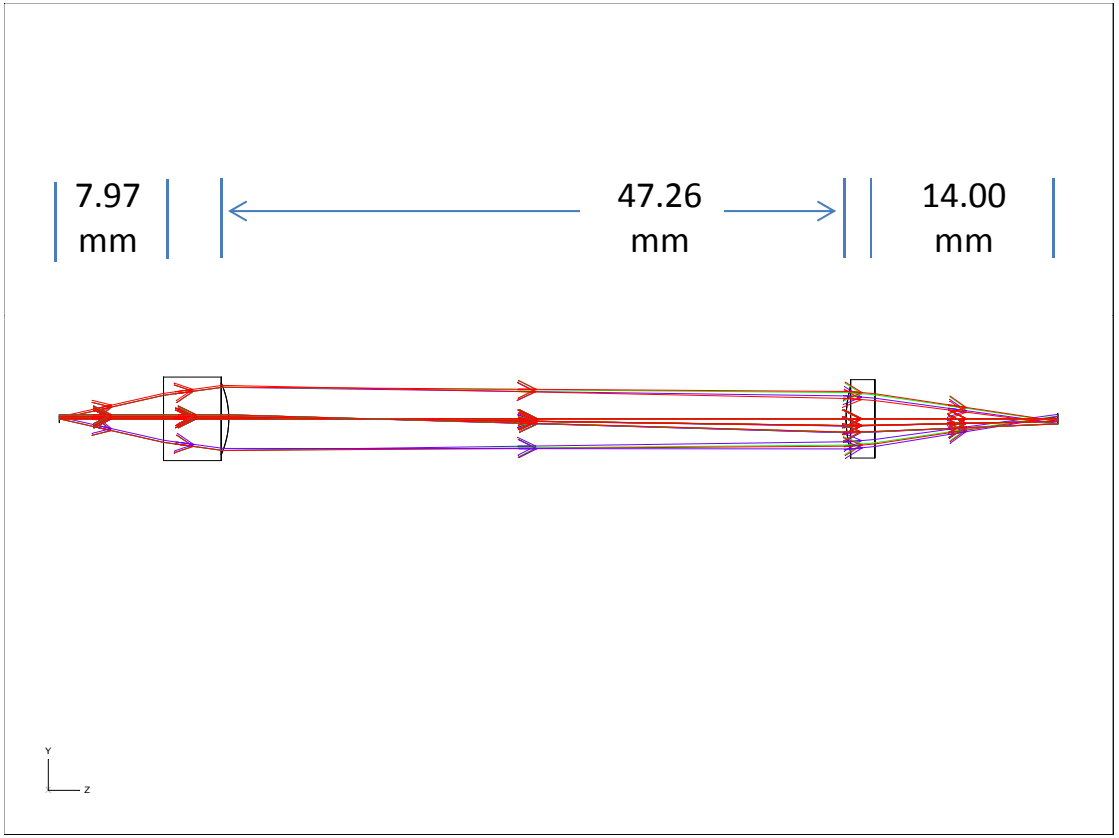


Throughput for nominal distances

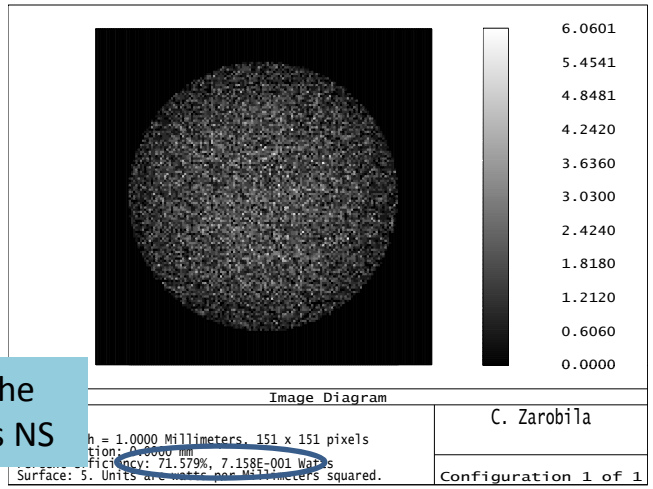


- The nominal separation between lenses is 47.26 mm
- 7.97 mm, 14.00 mm are back-focus distances of the lenses
- Given a fictitious 1 W of input power from the emitting fiber between 400 and 650 nm and simple AR coatings for the lenses…
- **…about 68% of the light gets through to the receiving fiber core**
- Will check origin of loss with sequential raytrace, but it is probably due to the CA's of the lenses and the circular footprint of the image being larger than 800 microns (due to lens aberrations – remember the collimators are designed for single-mode fiber)

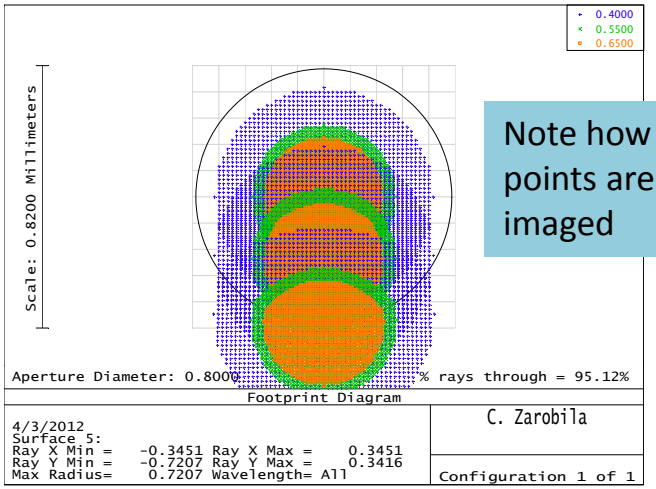
Sequential Raytrace



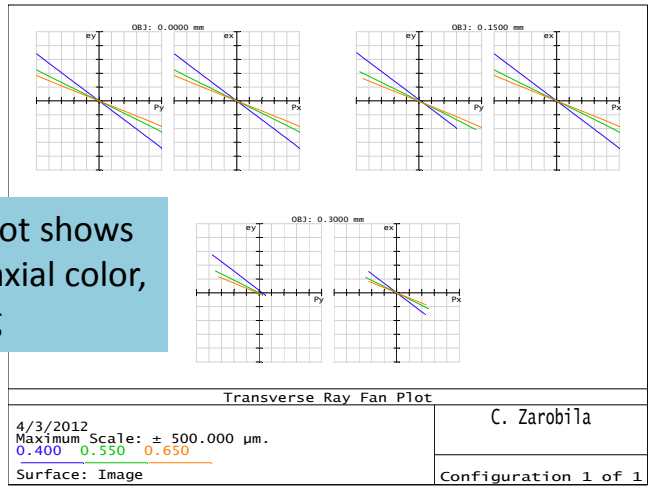
Results…



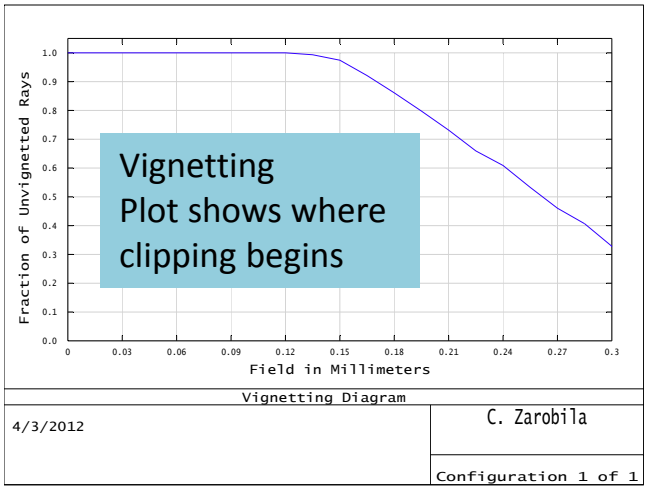
About the same as NS



Note how field points are imaged



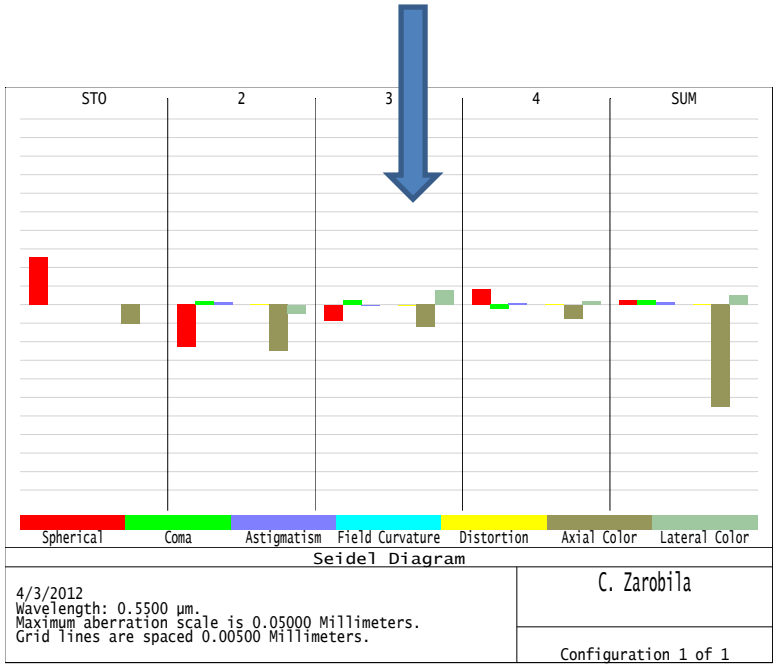
Ray fan plot shows defocus, axial color, vignetting



Vignetting
Plot shows where clipping begins

Sequential Conclusions

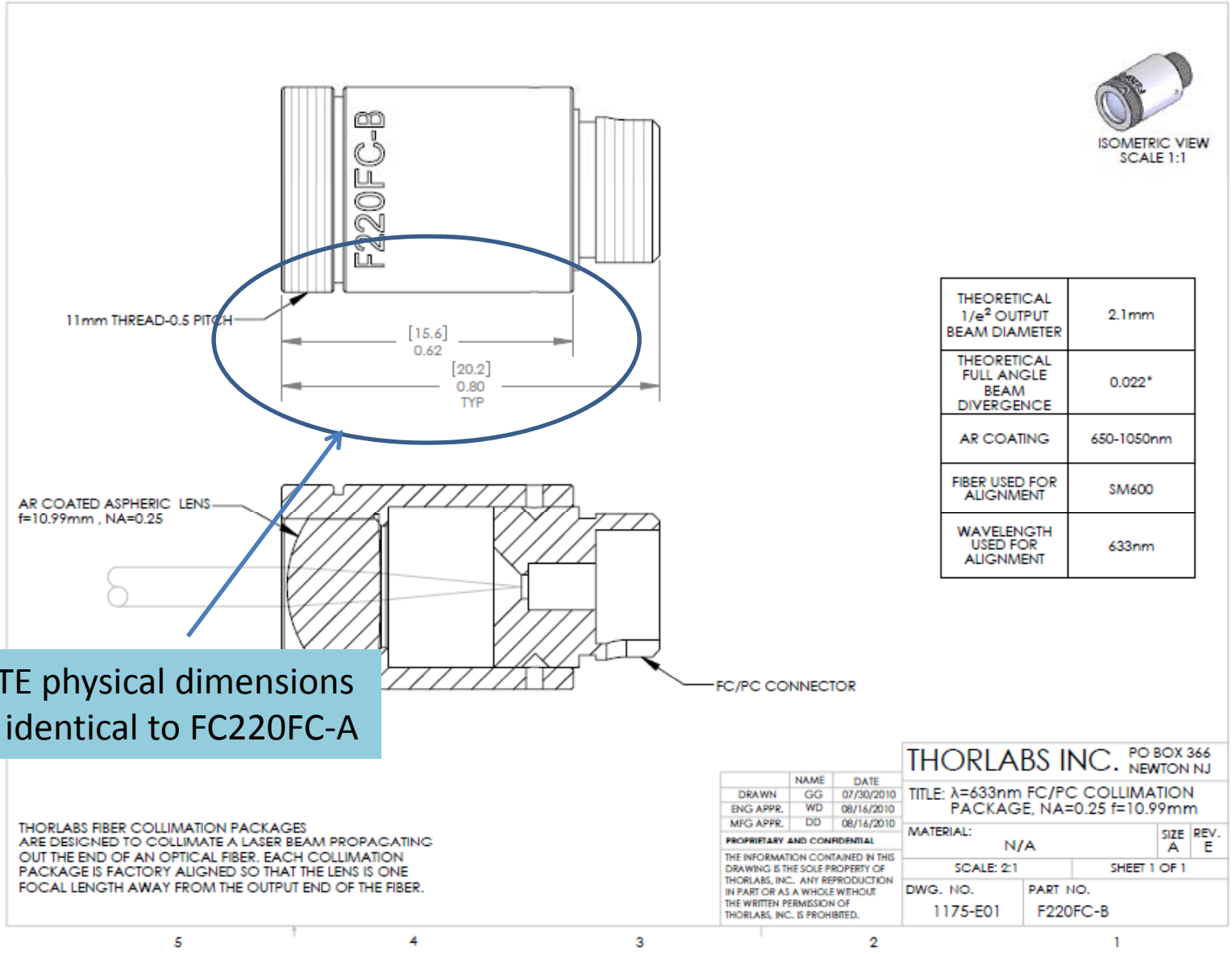
- The Clear Aperture (CA) of the lenses are a little small to permit all of the light through
- Defocus is shown; the only adjustment available is the inter-lens distance but this probably won't do much…tinker
- Axial color is the dominant aberration: check Seidel diagram



Expect to lose about 30% of the light from the emitting fiber (does not include 4% at RCVR air-glass fiber interface); BUT, for COTS collimators, OK. What other choice exists?

We should be able to do better with a custom design in the future if that is an option

F220FC-B Housing



THEORETICAL $1/e^2$ OUTPUT BEAM DIAMETER	2.1mm
THEORETICAL FULL ANGLE BEAM DIVERGENCE	0.022°
AR COATING	650-1050nm
FIBER USED FOR ALIGNMENT	SM600
WAVELENGTH USED FOR ALIGNMENT	633nm

NOTE physical dimensions are identical to FC220FC-A

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	NAME	DATE
DRAWN	GG	07/30/2010
ENG APPR.	WD	08/16/2010
MFG APPR.	DD	08/16/2010

PROPRIETARY AND CONFIDENTIAL

THORLABS INC. PO BOX 366 NEWTON NJ

TITLE: λ=633nm FC/PC COLLIMATION PACKAGE, NA=0.25 f=10.99mm

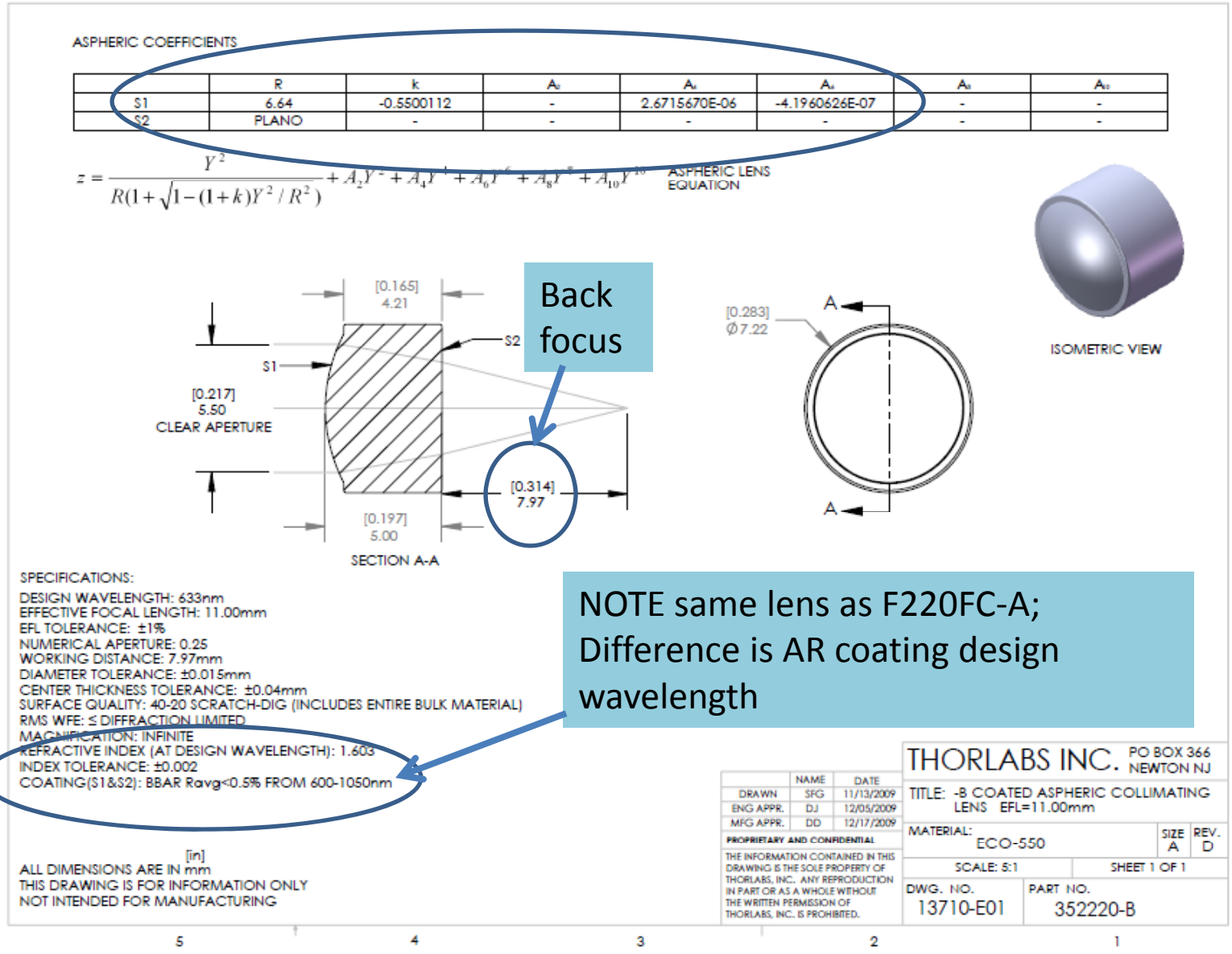
MATERIAL: N/A | SIZE A | REV. E

SCALE: 2:1 | SHEET 1 OF 1

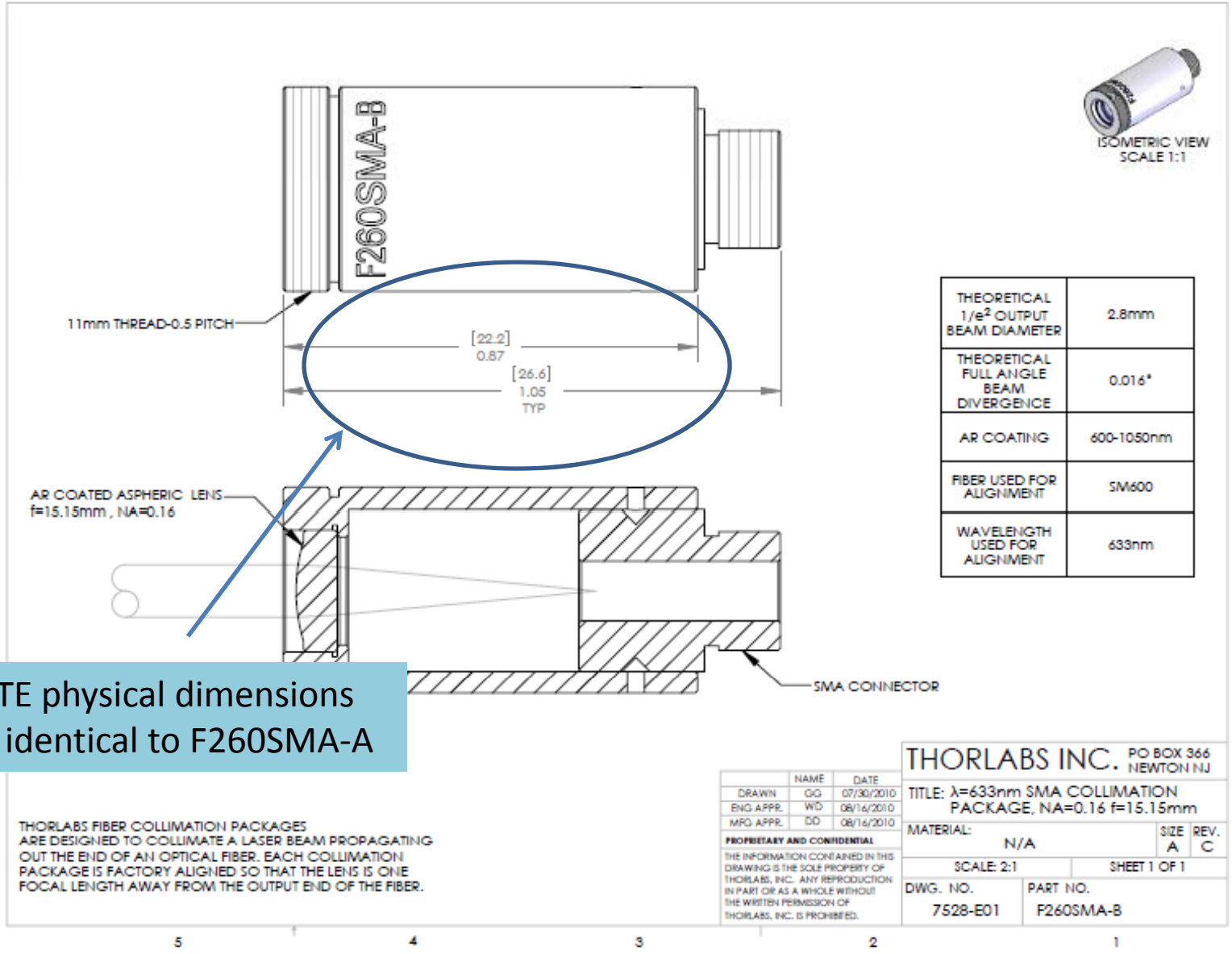
DWG. NO. 1175-E01 | PART NO. F220FC-B

5 4 3 2 1

F220FC-B aspheric lens, best-guess



F260SMA-A Housing



THEORETICAL $1/e^2$ OUTPUT BEAM DIAMETER	2.8mm
THEORETICAL FULL ANGLE BEAM DIVERGENCE	0.016°
AR COATING	600-1050nm
FIBER USED FOR ALIGNMENT	SM600
WAVELENGTH USED FOR ALIGNMENT	633nm

NOTE physical dimensions are identical to F260SMA-A

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	NAME	DATE
DRAWN	GG	07/30/2010
ENG APPR.	WD	08/16/2010
MFG APPR.	DD	08/16/2010

THORLABS INC. PO BOX 366 NEWTON NJ

TITLE: λ=633nm SMA COLLIMATION PACKAGE, NA=0.16 f=15.15mm

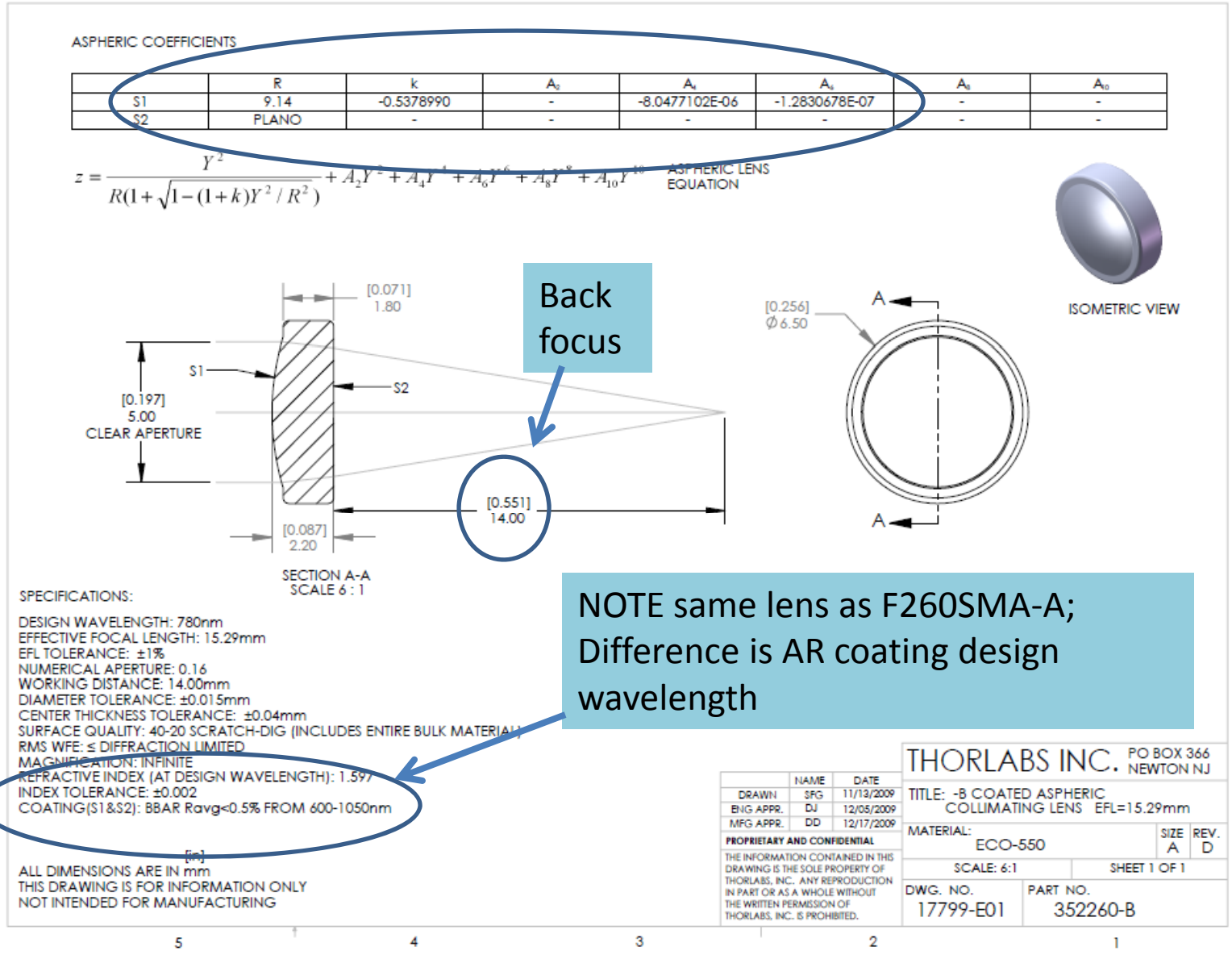
MATERIAL: N/A | SIZE A | REV. C

SCALE: 2:1 | SHEET 1 OF 1

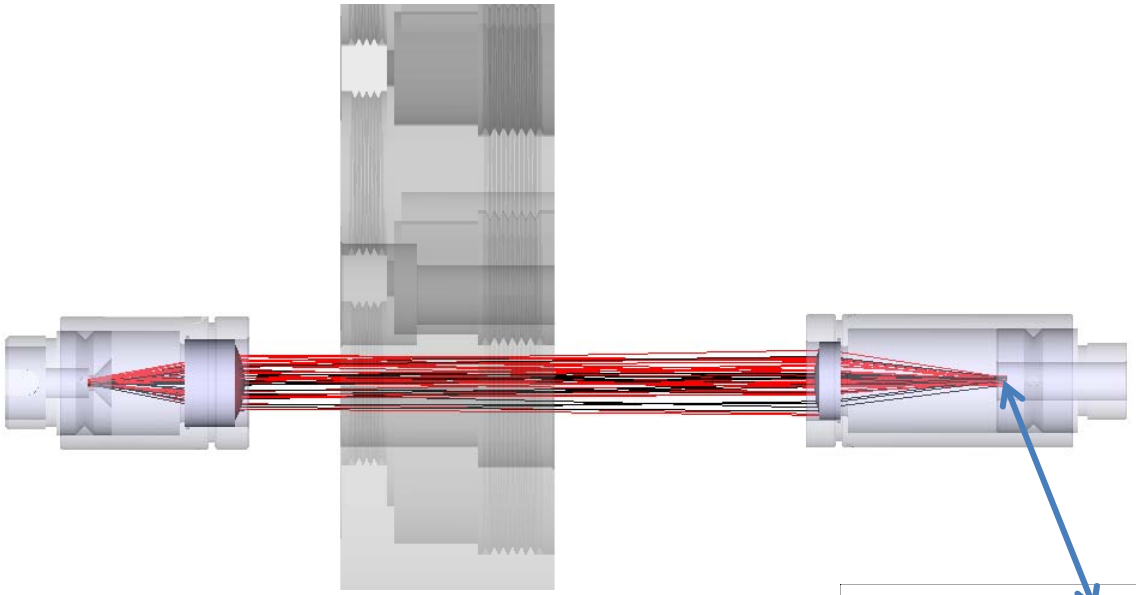
DWG. NO. 7528-E01 | PART NO. F260SMA-B

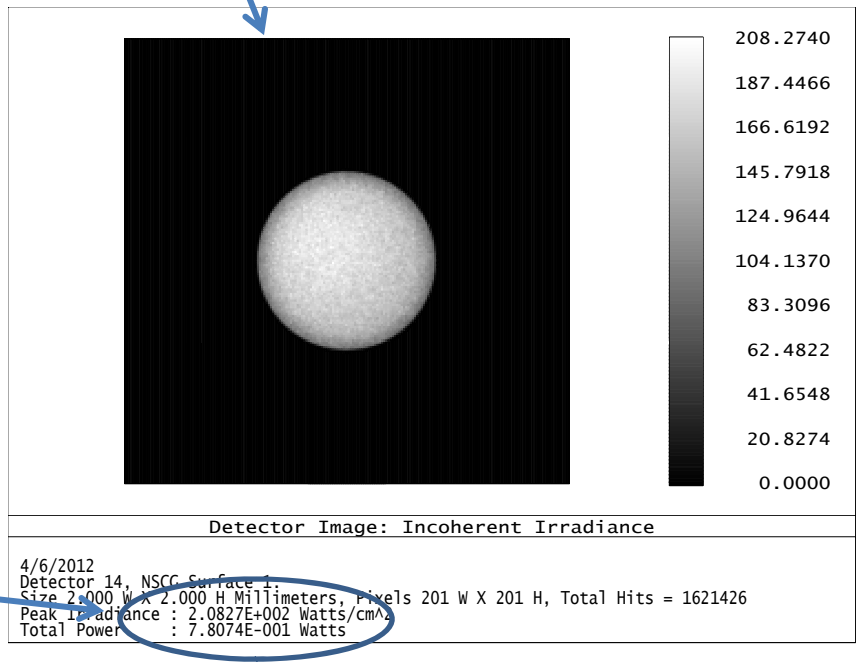
5 4 3 2 1

F260SMA-B aspheric lens, best-guess



Red throughput

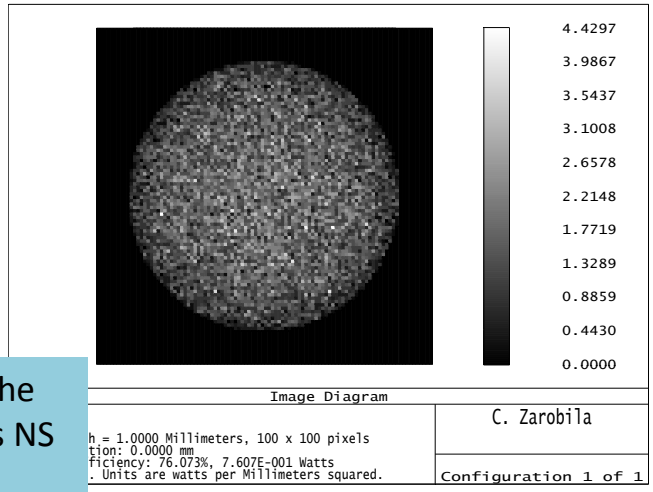




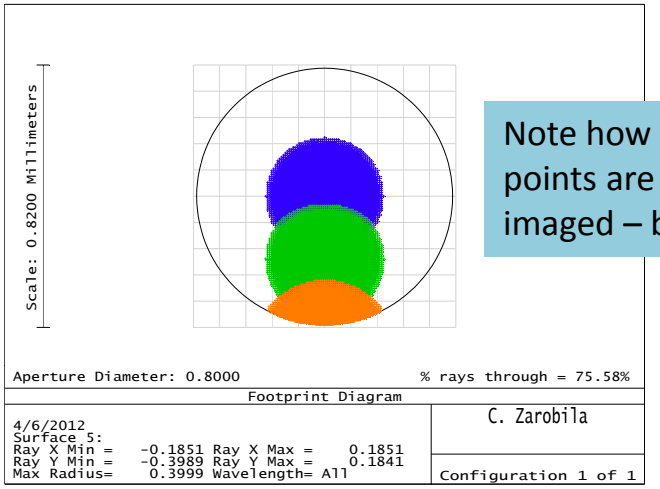
- The nominal separation between lenses is 47.26 mm as before
- 7.97 mm, 14.00 mm are back-focus distances of the lenses as before
- Given a fictitious 1 W of input power from the emitting fiber between 650 and 950 nm and simple AR coatings for the lenses…

…about 78% of the light gets through to the receiving fiber core. Better than before!

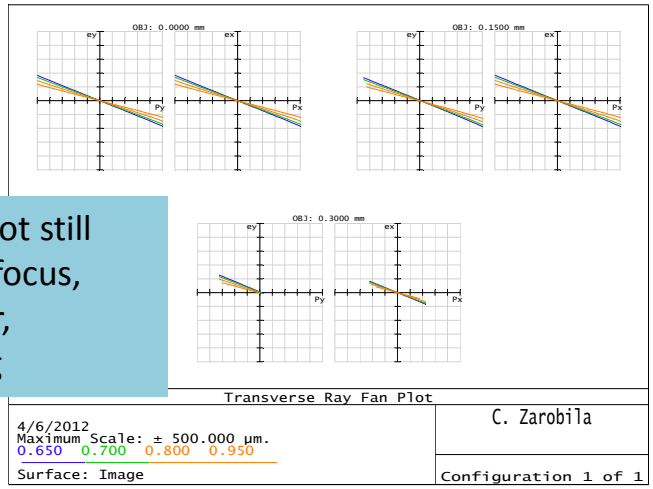
Red Sequential Results



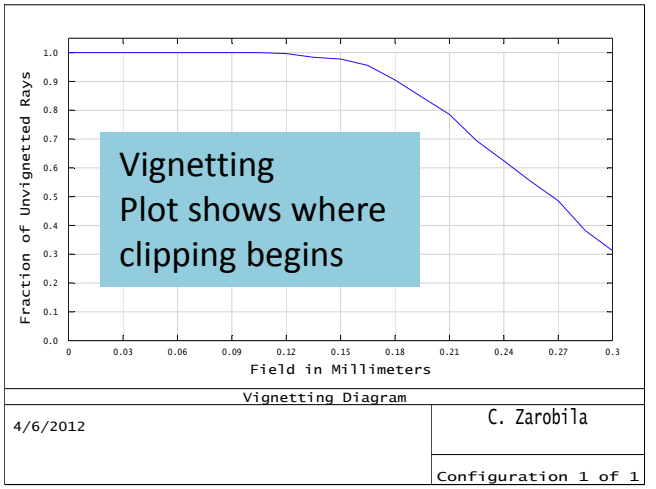
About the same as NS Good!



Note how field points are imaged – better!



Ray fan plot still shows defocus, axial color, vignetting



Vignetting
Plot shows where clipping begins