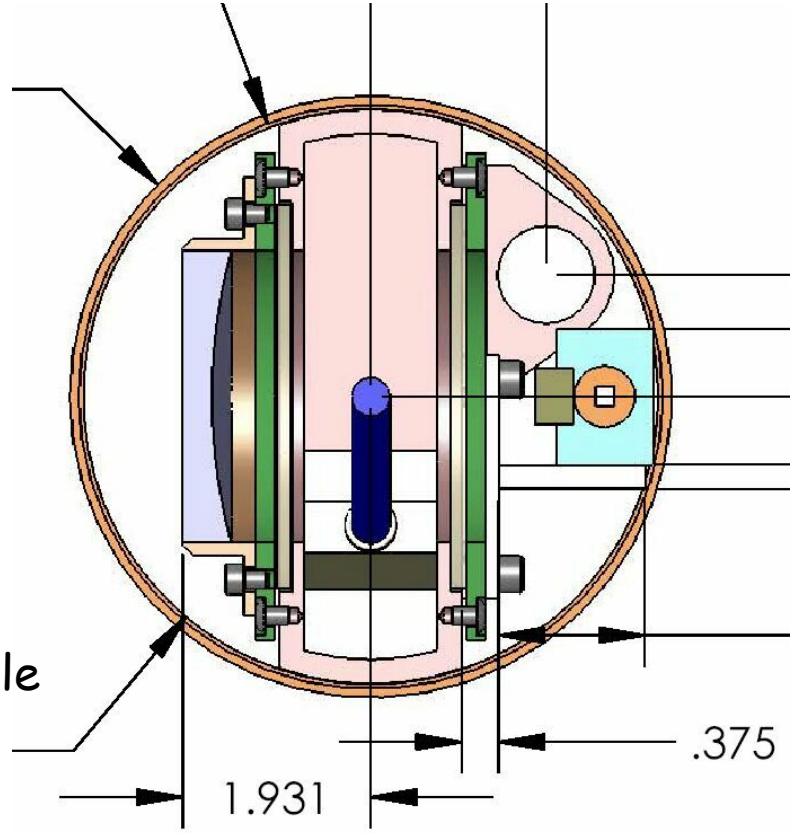
Optical Diagnostics

01-13-2006

BROOKHAVEN NATIONAL LABORATORY

Instrumentation Division Ultrafast Laser Laboratory

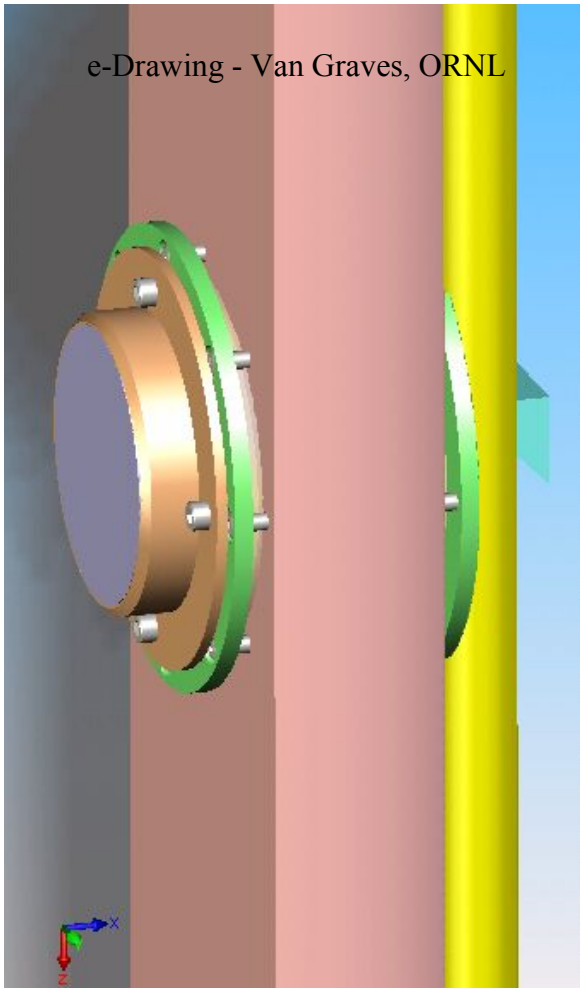
- tight environment
- high radiation area
- non-serviceable area
- passive components
- optics only, no active electronics
- transmit image through flexible fiber bundle

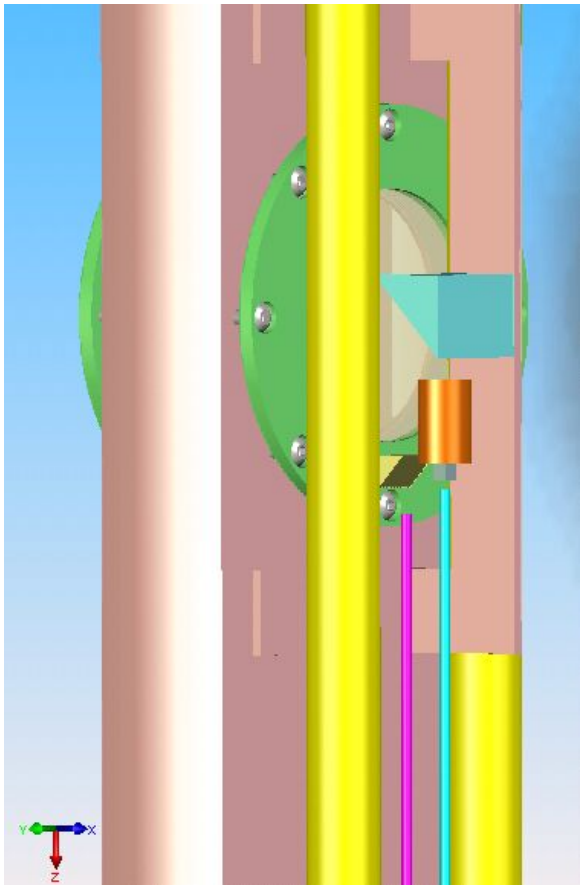


Optical Diagnostics

optical design in secondary containment

BROOKHAVEN NATIONAL LABORATORY
Instrumentation Division Ultrafast Laser Laboratory





One set of optics per viewport

Conceptual design completed

- issues on the imaging fiber bundle

Fujikura imaging fibers

Table 3

ULTRATHIN IMAGEFIBER SPECIFICATIONS

(FIGH series N-Type 50k-100k)

Item	FIGH-50-1100N	FIGH-70-1300N	FIGH-100-1500N
Number of picture elements (nominal)	50,000 (Nominal)	70,000 (Nominal)	100,000 (Nominal)
Imagecircle diameter (μm)	1,025 +80/-80	1,200 +100/-100	1,400 +120/-120
Fiber diameter (μm)	1,100 +80/-80	1,300 +100/-100	1,500 +120/-120
Coating diameter (μm)	1,200 +100/-100	1,450 +100/-100	1,700 +150/-150
Minimum bending radius (mm)	110*1(80*2)	150*1(100*2)	200*1(130*2)
Coating material	Silicone resin		
Lattice defect (%)	< 0.1		
Uncirculality (%)	< 5		

*1:Minimum bending radius in storage
*2:Recommended bending radius in use (For your reference only, possibly to be happened breakage by static fatigue.)

ULTRATHIN IMAGEFIBER SPECIFICATIONS
(FIGH series S-Type 1.6k-10k)

Table 1

Item	FIGH-016-160S	FIGH-03-215S	FIGH-06-300S	FIGH-10-350S
Number of picture elements_(nominal)	1,600	3,000	6,000	10,000
Imagecircle diameter (um)	140 ± 15	190 ± 20	270 ± 20	325 ± 20
Fiber diameter (um)	160 ± 20	215 ± 25	300 ± 25	350 ± 25
Coating diameter (um)	210 ± 30	285 ± 30	400 ± 30	450 ± 30
Minimum bending radius(mm)	20 *1_10 *2_	25 *1_15 *2_	30 *1_15 *2_	35 *1_20 *2_
Coating material	Silicone resin			
Lattice defect (%)	< 0.1			
Uncirculality (%)	< 5			
Length/pc	Maximum length of 1pc : 30ft Cut and rough polish are available. Cut length of 1pc : Customer order			

*1:Minimum bending radius in storage
*2:Recommended bending radius in use

ULTRATHIN IMAGEFIBER SPECIFICATIONS
(FIGH series N-Type 10k-15k)

Table 2

Item	FIGH-10-500N	FIGH-15-600N
Number of picture elements(nominal)	10,000	15,000
Imagecircle diameter (um)	460 ± 25	550 ± 30
Fiber diameter (um)	500 ± 25	600 ± 30
Coating diameter (um)	600 ± 35	700 ± 35
Minimum bending radius (mm)	50 *1_25 *2_	60 *1_30 *2_
Coating material	Silicone resin	
Lattice defect (%)	< 0.1	
Uncirculality (%)	< 5	
Length/pc	Maximum length of 1pc : 30ft Cut and rough polish are available. Cut length of 1pc : Customer order	

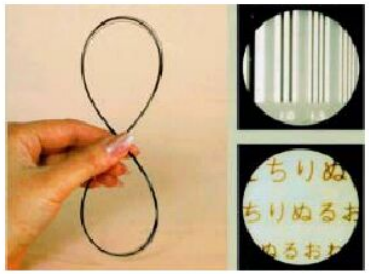
*1:Minimum bending radius in storage
*2:Recommended bending radius in use

ULTRATHIN IMAGEFIBER SPECIFICATIONS
(FIGH series N-Type 50k-100k)

Table 3

Item	FIGH-30-850N	FIGH-50-1100N	FIGH-70-1300N	FIGH-100-1500N
Number of picture elements(nominal)	30,000	50,000	70,000	100,000
Imagecircle diameter (um)	790 ± 50	1,025 ± 80	1,200 ± 100	1,400 ± 120
Fiber diameter (um)	850 ± 50	1,100 ± 80	1,300 ± 100	1,500 ± 120
Coating diameter (um)	950 ± 50	1,200 ± 100	1,450 ± 100	1,700 ± 150
Minimum bending radius (mm)	90 *1_50 *2_	110 *1_80 *2_	150 *1_100 *2_	200 *1_130 *2_
Coating material	Silicone resin			
Lattice defect (%)	< 0.1			
Uncirculality (%)	< 5			
length/pc	Maximum length of 1pc : 10ft Cut and rough polish are available. Cut length of 1pc : Customer order			

Sumitomo imaging fibers



TP03105B

SEI

Product Lineup

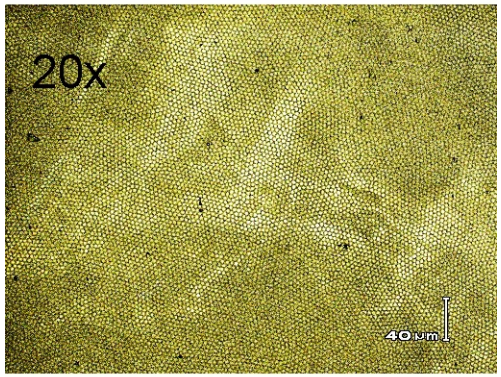
	IGN-02/03	IGN-028/06	IGN-035/06	IGN-037/10	IGN-05/10	IGN-08/30	IGN-15/30	IGN-20/50
Number of picture elements	3,000	6,000	6,000	10,000	10,000	30,000	30,000	50,000
Jacketing diameter (um)	200	280	350	370	500	800	1,500	2,000
Picture elements area diameter (um)	180	252	315	333	450	720	1,350	1,800
Coating diameter (Primary) (um)	250	340	420	450	590	960	1,900	2,400
Coating diameter (Secondary) (um)	---	---	---	---	---	---	2,500	3,000
Circularity	>= 0.93							
Core material	GeO2 Containing Silica							
Cladding material	F Containing Silica						Pure Silica	
Coating material	Silicone						Silicone + PFA	
Numerical aperture	0.35						0.30	
Lattice defect (%)	<= 0.1							
Allowable bending radius (mm)	10	15	15	20	25	40	75	100
Allowable max temp. (C)	150							

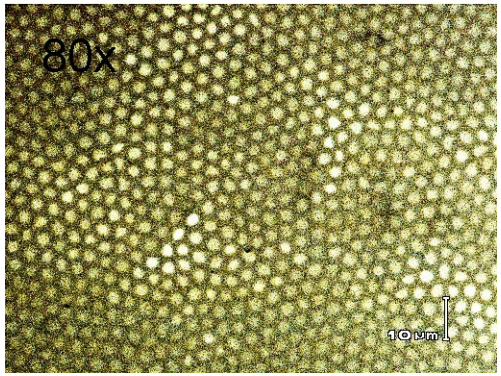
SUMITOMO ELECTRIC

4

All have small imaging area <2 mm diameter

IGN-08/20 - sample





More imaging fibers (*glass*)

SMD camera

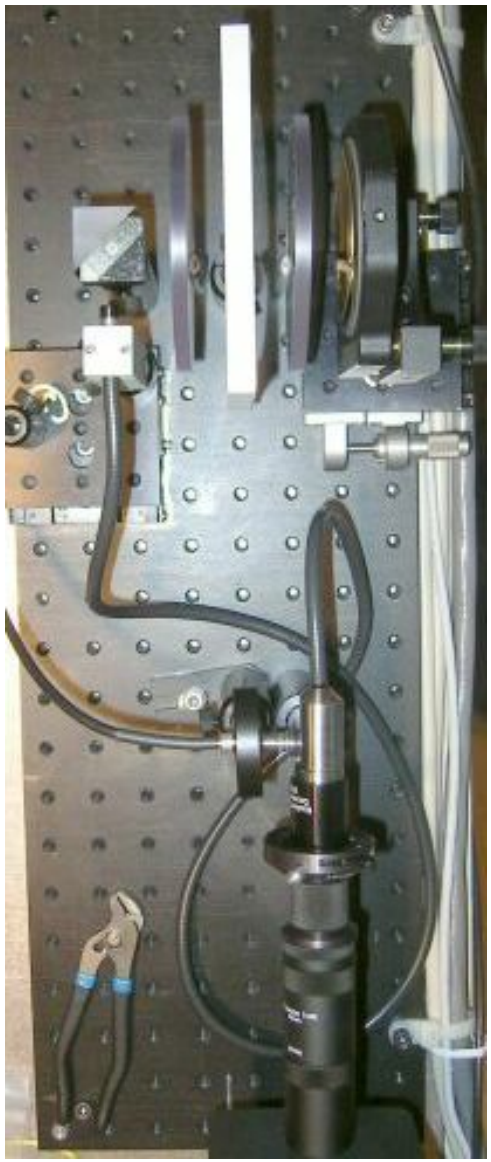
CCD size:	13.4 x 13.4 mm
Pixels:	960x960
Single frame:	240x240 pixels
	57,600 picture elements
Reduced pixel size:	56 x 56 um

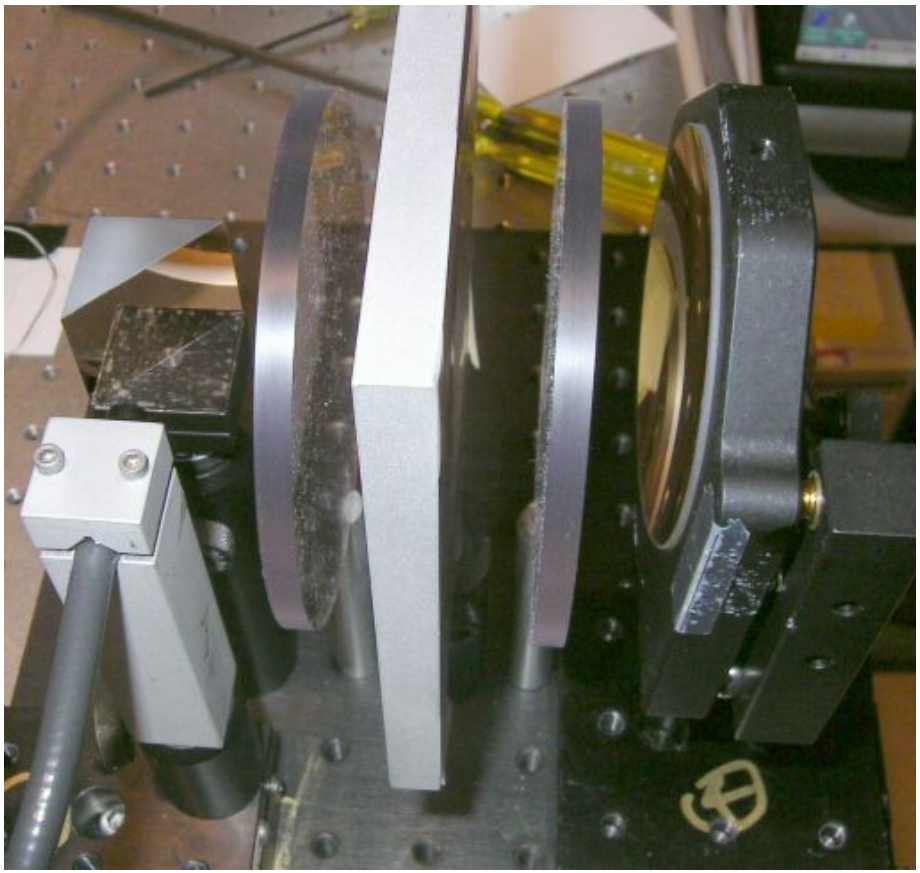
Hawkeye flexible borescope

18,000 glass fibers
fiber diameter 6 μm
bundle diameter ~ 1-mm
8-mm outer diameter
FOV 40 deg
DOF 15-mm to infinity
Length: 1-meter

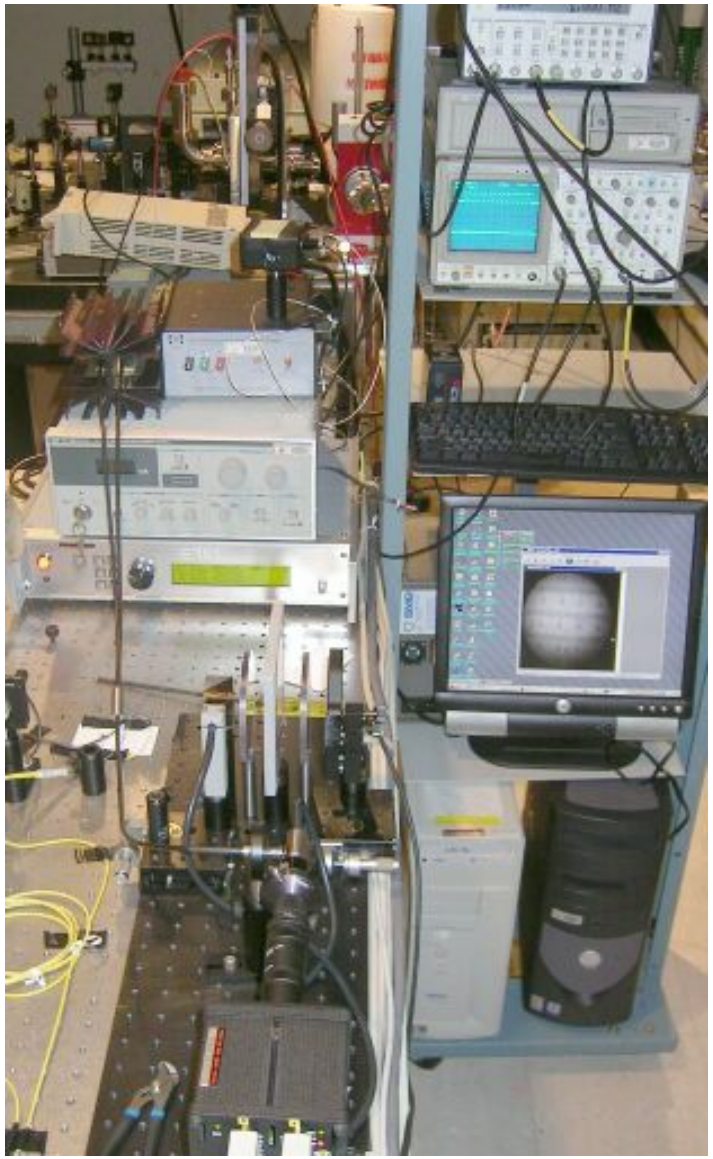
total fiber counts ~18,000 in 1 mm diameter
Imaging ~150 x 150 fibers on 240 x 240 CCD array
~1 imaging fiber on ~1.6 pixel on a single frame

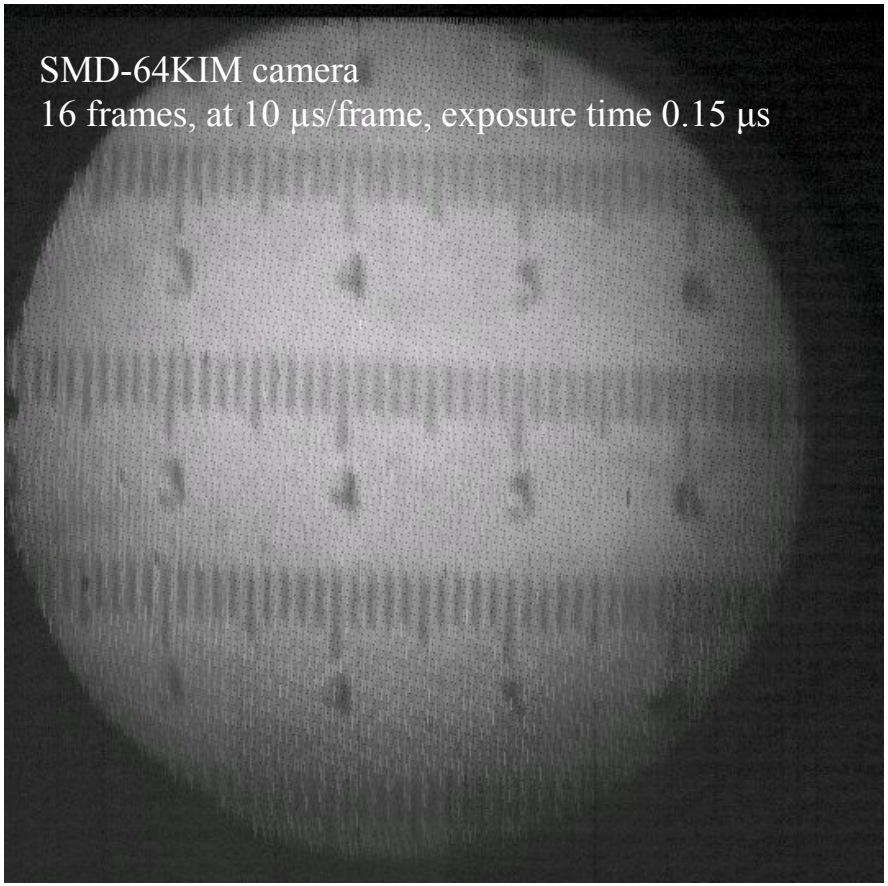
borescope retroreflected illumination





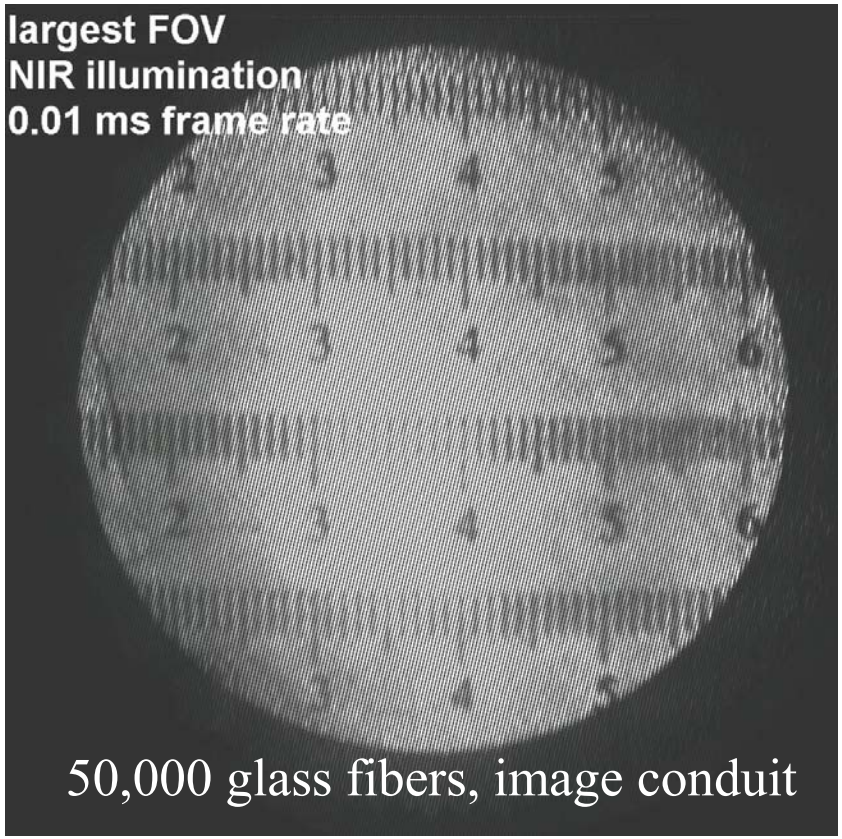
laser borescope retroreflected illumination



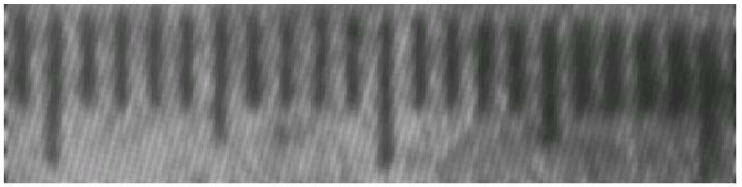


total fiber counts ~18,000 in 1 mm diameter
Imaging φ=150 fibers on 240 x 240 CCD array
~1 imaging fiber on ~1.6 pixel on a single frame

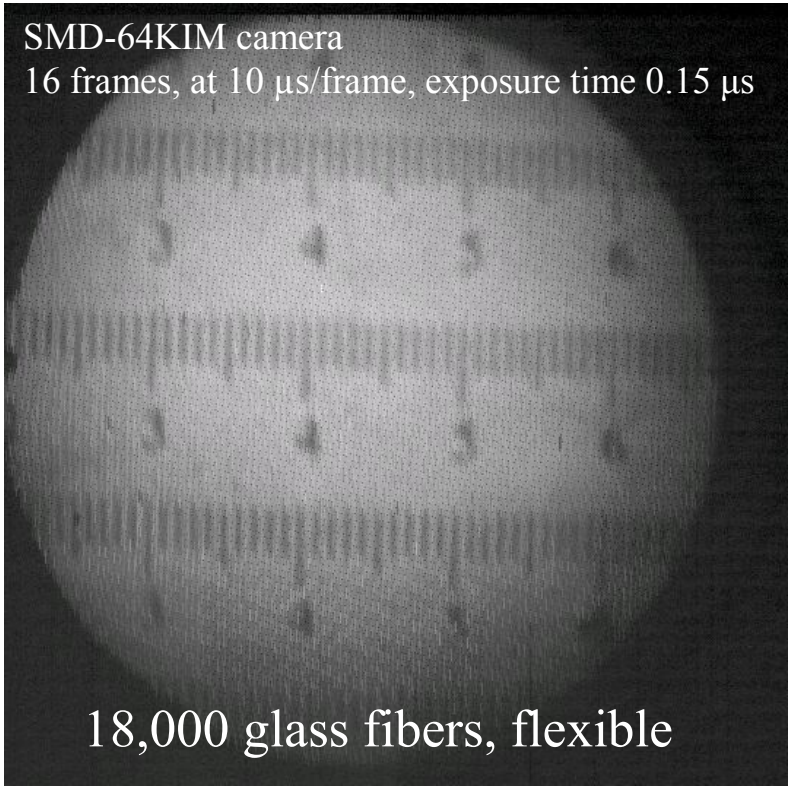
image quality comparison



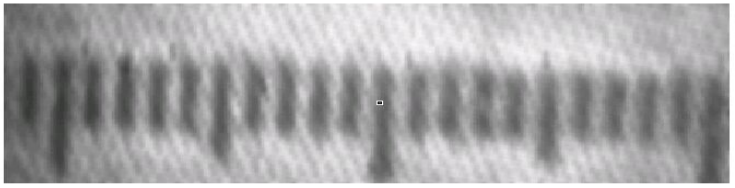
50,000 glass fibers, image conduit



Sumitomo 30,000 fibers image ??



18,000 glass fibers, flexible

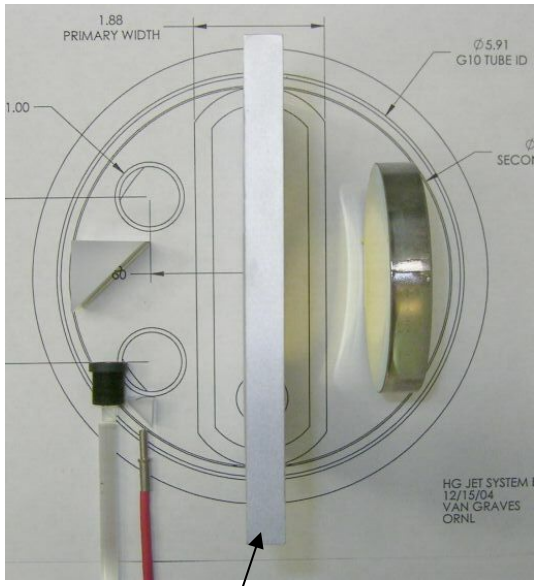


Optical Diagnostics

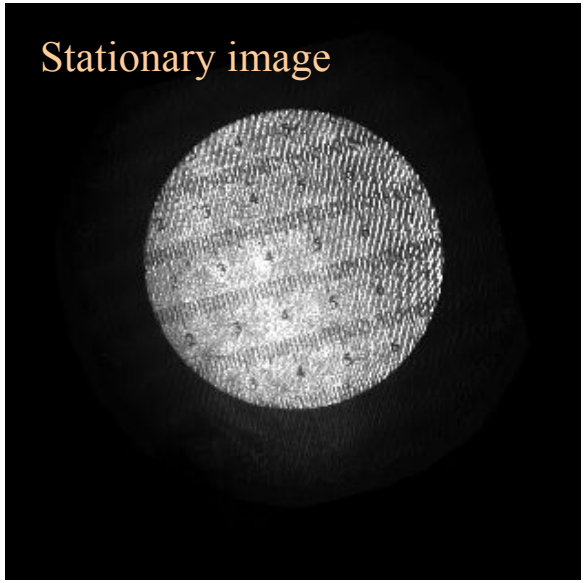
An optical chopper in motion @ 4 kHz

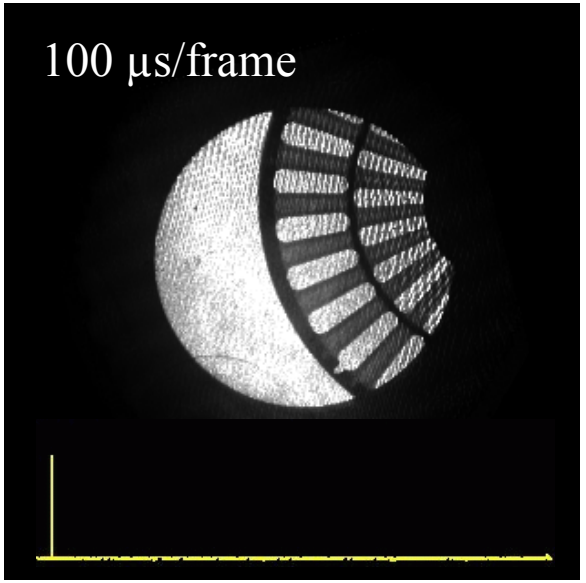
BROOKHAVEN NATIONAL LABORATORY

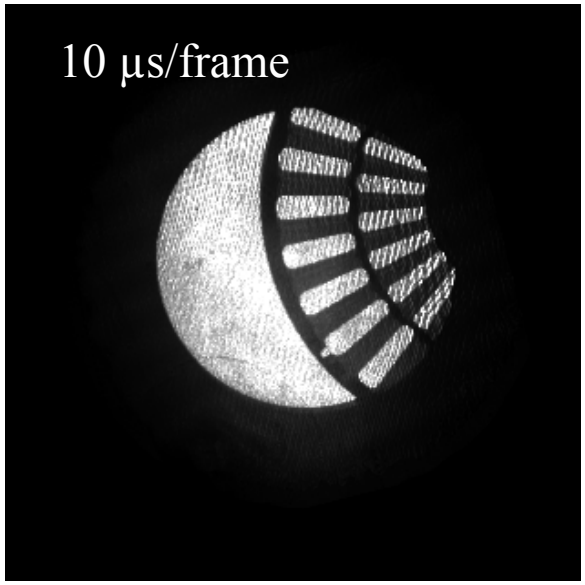
Instrumentation Division Ultrafast Laser Laboratory

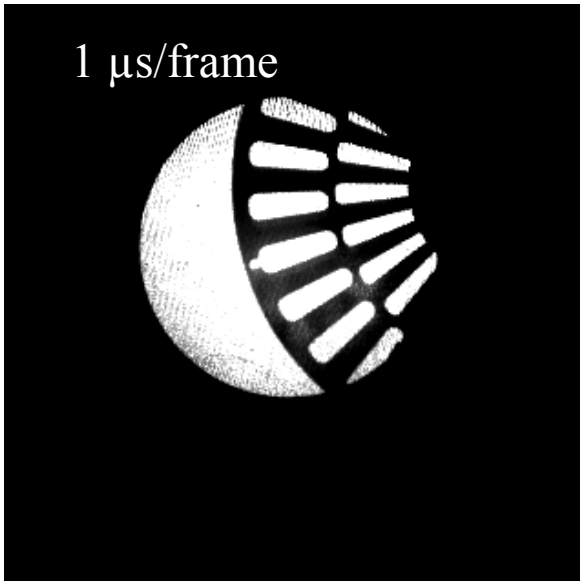


Velocity @ ~40 m/s



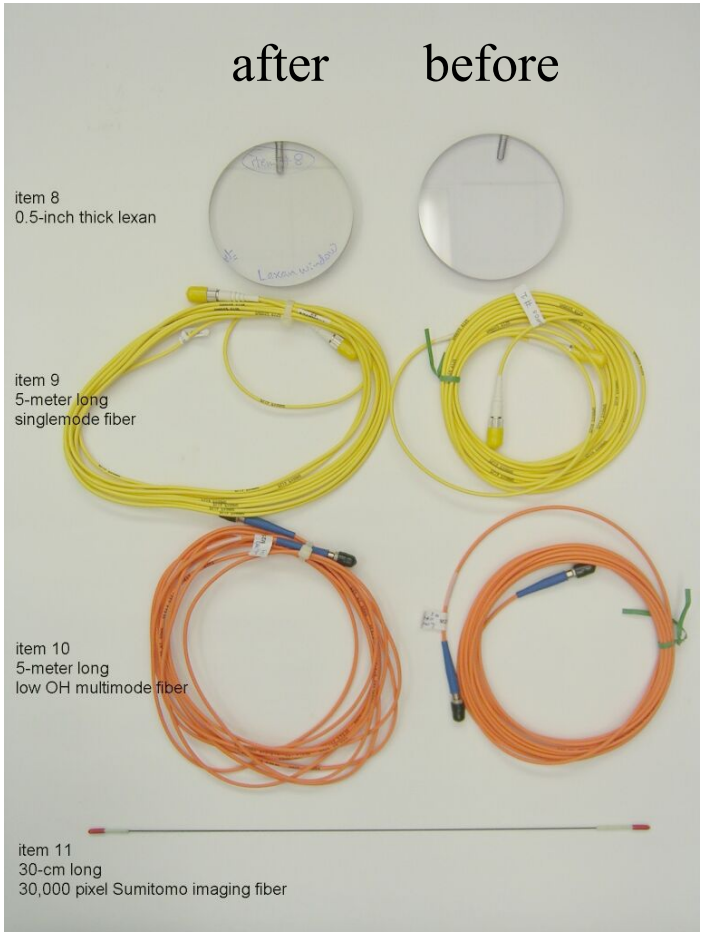






Irradiation Studies of Optical Components - II

CERN, week of Oct. 24, 2005
1.4 GeV proton beam
4 x 10^{15} proton
Irradiation dose: equivalent to
40 pulses of 24 GeV proton beam
28 TP/pulse
total of 1.2 x 10^{15} proton



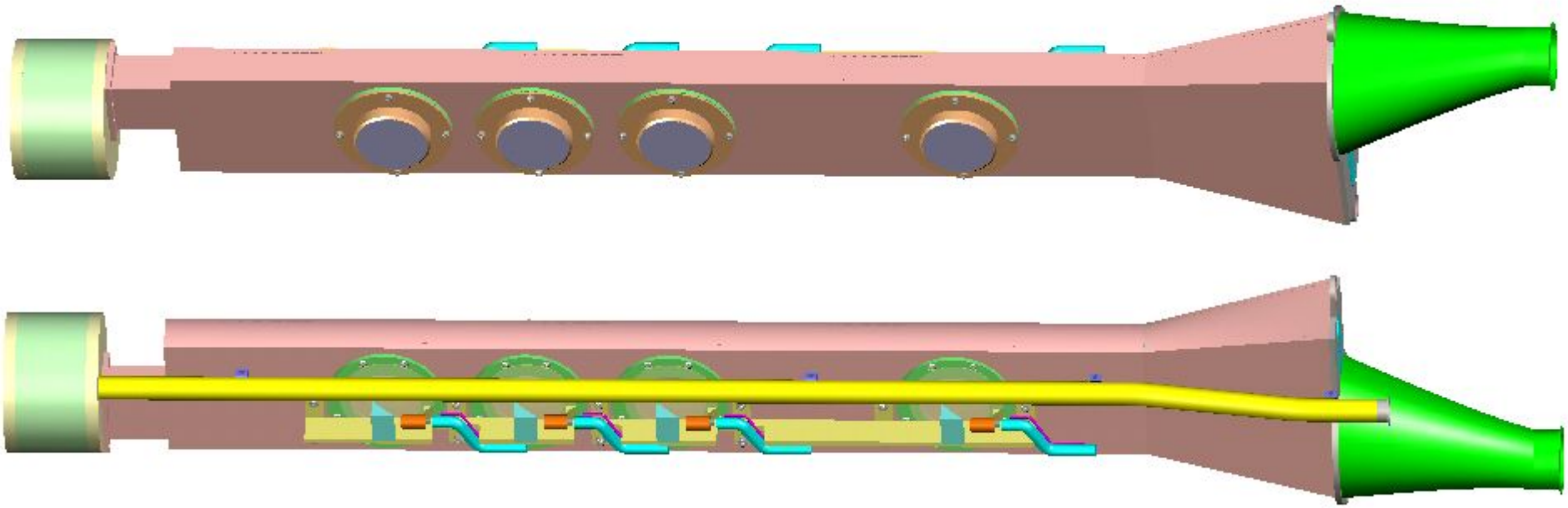
Microsoft Excel - CERN_2nd_irradiation_summary.xls

	A	B	C	D	E	F	G	H	I
1		28-Dec-2005							
2		Results of optical components irradated at CERN on Oct. 24, 2005							
3		proton beam energy: 1.4 GeV							
4		no. of protons: 5x10^15							
5		transmittance measurements at 650 & 850 nm wavelengths							
6									
7			wavelength @ 650 nm				wavelength @ 850 nm		
9	item #	components	before	after	results		before	after	results
11	8	0.5-inch thick Lexan window	0.840	0.830	no change		0.940	0.900	drop 4%
12	9	5-meter singlemode fiber	0.600	0.022	drop 96%		0.420	0.330	drop 22%
13	10	5-meter multimode low-OH fiber	0.830	0.850	no change		1.000	1.020	no change
14	11	30-cm long Sumitomo imaging fiber	0.850	0.640	drop 25%		0.670	0.710	no change
16		overall radiation activity ~ 3 times above background on dec 16, 2005							

Sheet1 Sheet2 Sheet3
Ready

Sumitomo imaging fiber 30,000 pixel is rad-hard to 1Mrad

One set of optics per viewport



- tight environment
- high radiation area
- non-serviceable area
- passive components
- optics only, no active electronics
- transmit image through flexible fiber bundle