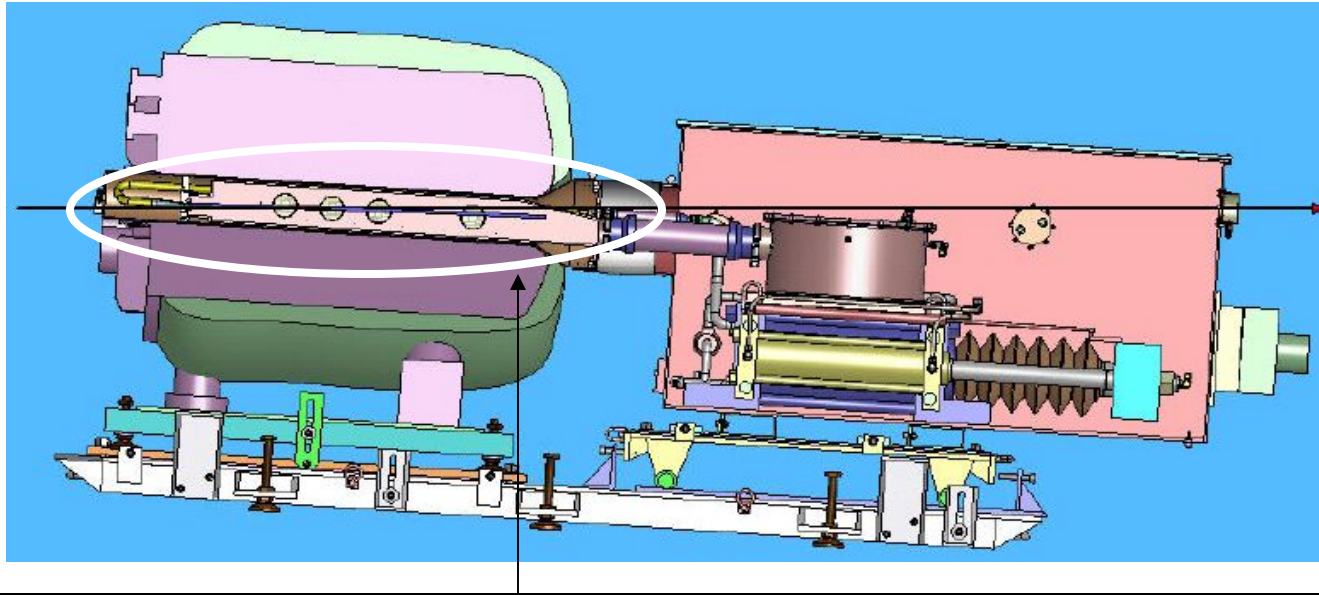




Optical Diagnostics *Thomas Tsang, BNL, Oct 20, 2006*



tight environment

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

Optical diagnostic tool:
high-speed camera to fast record transient phenomena

- back illuminated laser shadow photography technique
- freeze the image of events using high speed camera (up to 1 μ s/frame)
- synchronized arrival of short laser light pulses illuminate onto the target
- the motion of the target after proton impact is freezed by high intensity short (150 ns) laser pulses
- 2-dimensional image

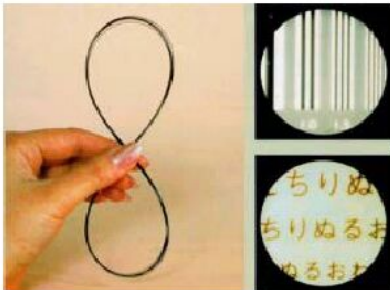


Sumitomo imaging fibers – used in our setup

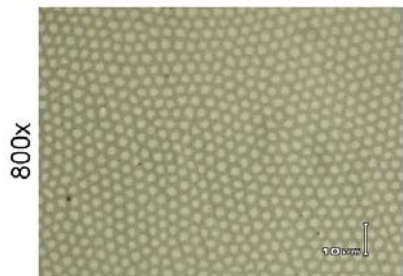
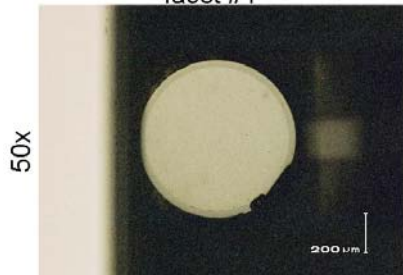
TP03105B



Product Lineup



IGN-08/30 sample
0.3-meter
30,000 pixels
facet #1



	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							

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SEI Proprietary and Confidential.

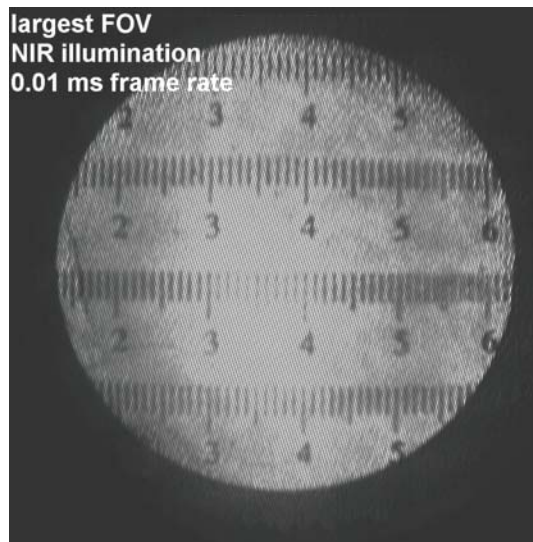
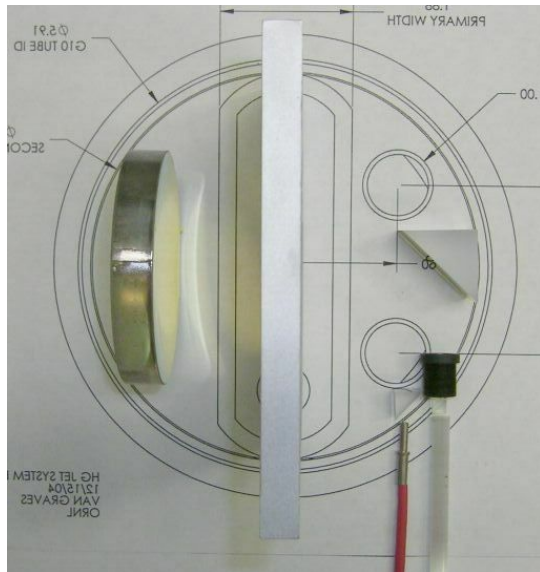
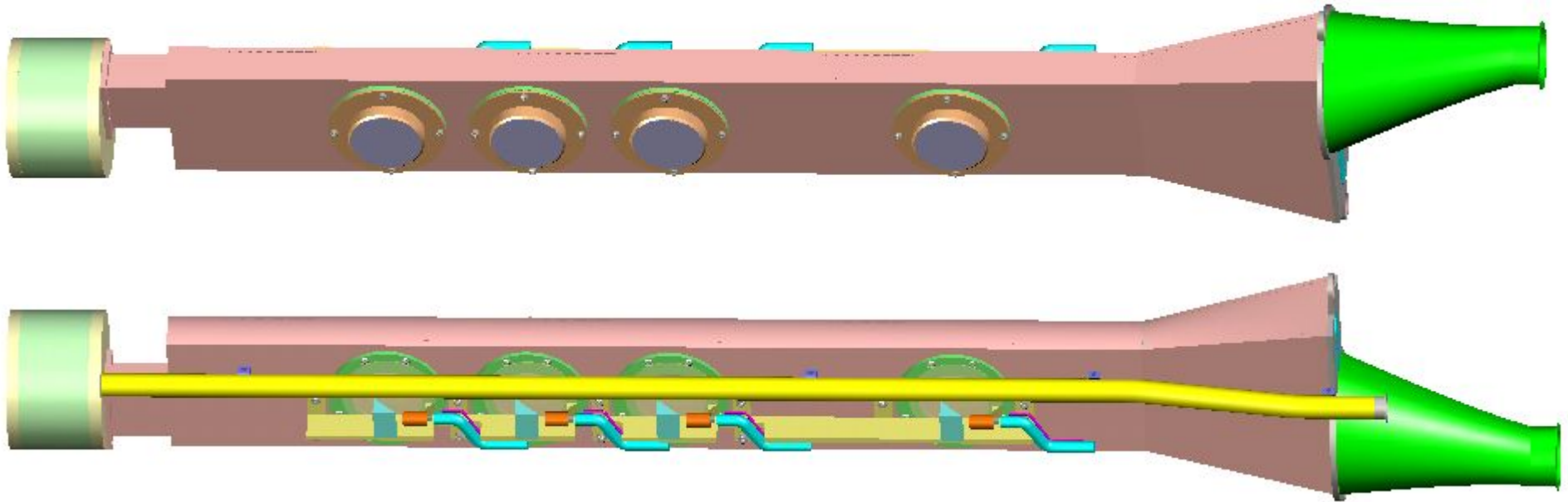


4

Cost per foot	\$78		
Cost in 10 meter	\$2574		
Total cost for 4 fibers (40 meter)	\$10.3k		

Rad-hard to 1 Mrad

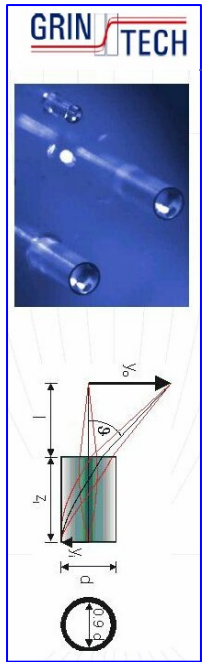
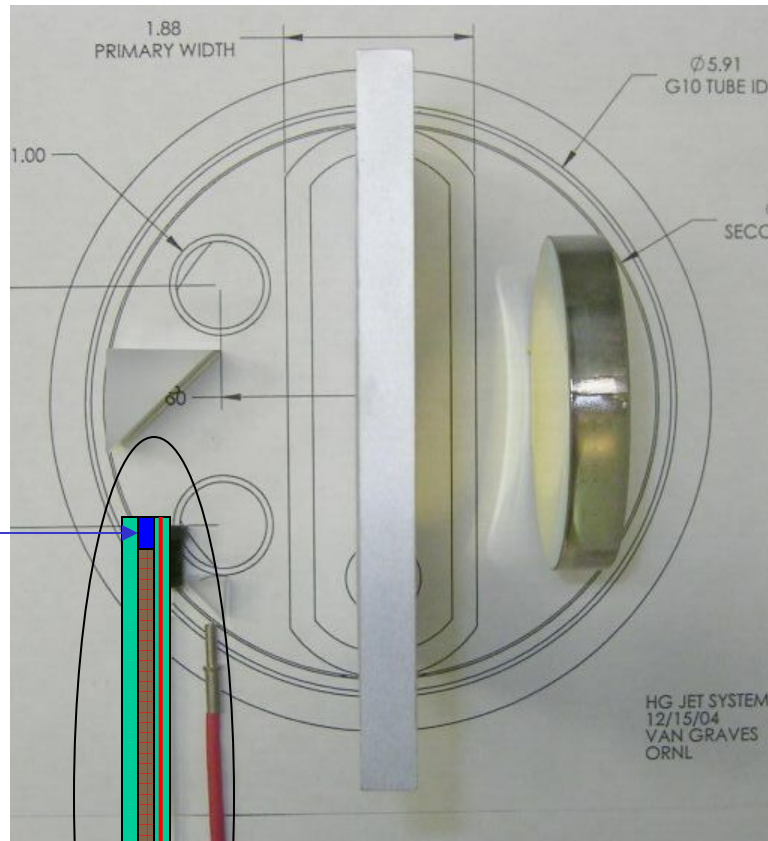
Optical Diagnostics in secondary containment



One set of optics
per viewport

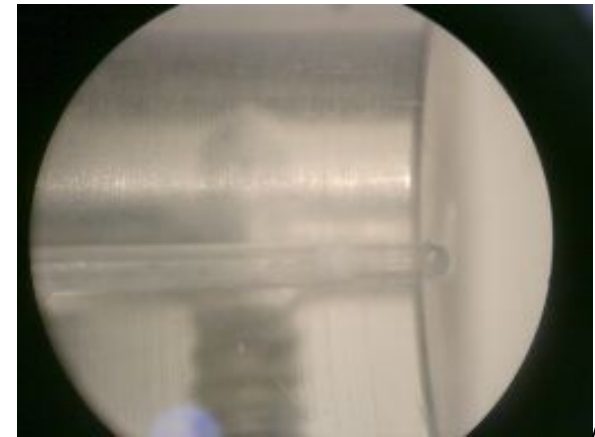
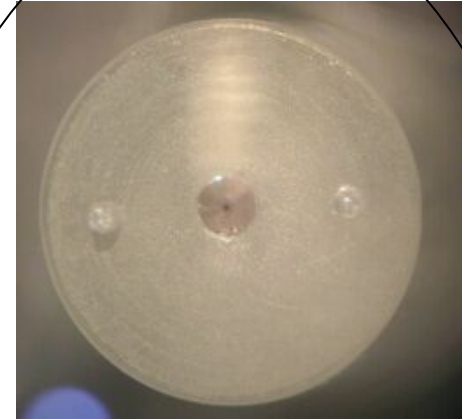
Conceptual design
completed

All-in-one optical setup



glass lens

- Grin objective lens
- imaging fiber – 1 mm
- illumination fiber
- fiber holder



Optical components irradiation using radiation sources #1 & #2

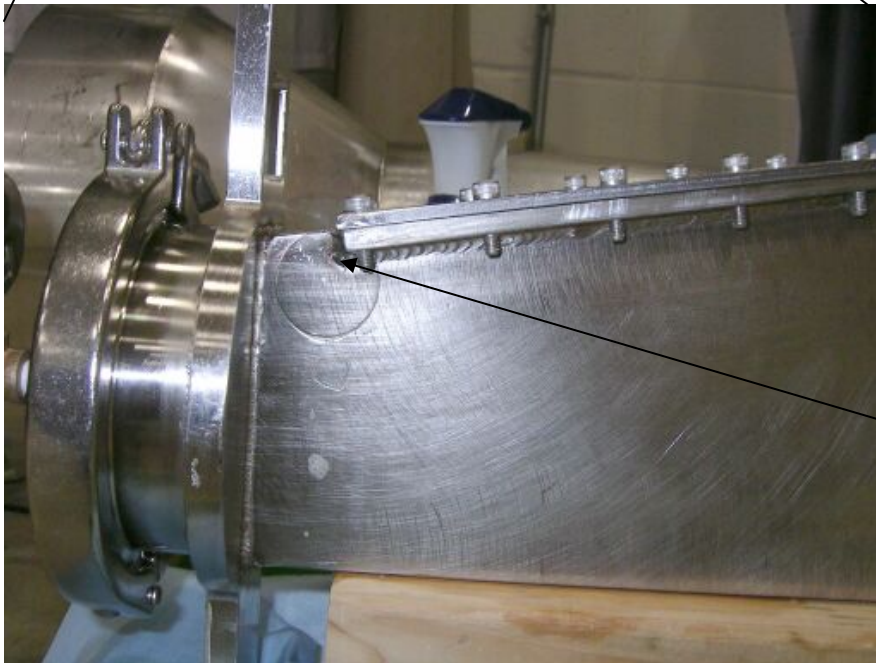
Source #1: CERN proton beam: 1.4 GeV, 5×10^{15} protons, 320 krad, equivalent to 40 pulses of 24 GeV proton

Source #2: BNL Co60: 30 krad & 3 Mrad equivalent to 3.7 & ~370 pulses of 24 GeV proton
measurements wavelength ~ 800 nm

item #	components	radiation source	equivalent proton pulse	NIR (~800nm)		results
				before	after	
1	gold mirror reflector	#1	40	0.910	0.920	no change
2	1-mm thick sapphire window (& ball lens)	#1	40	0.863	0.867	no change
3	5-meter multimode low-OH fiber	#1	40	1.000	1.020	no change
4	30-cm long Sumitomo imaging fiber	#1	40	0.670	0.710	no change
5	Grin objective lens, 2.43 mm long	#2	~4	0.900	0.860	T=95%
5	Grin objective lens, 2.43 mm long	#2	370	0.900	0.657	T=73%

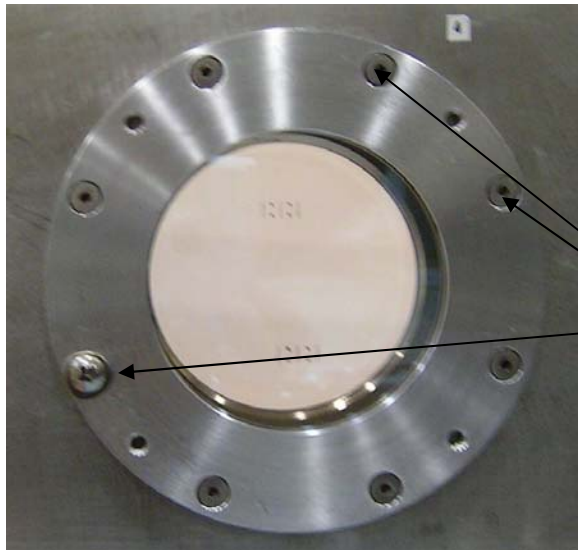
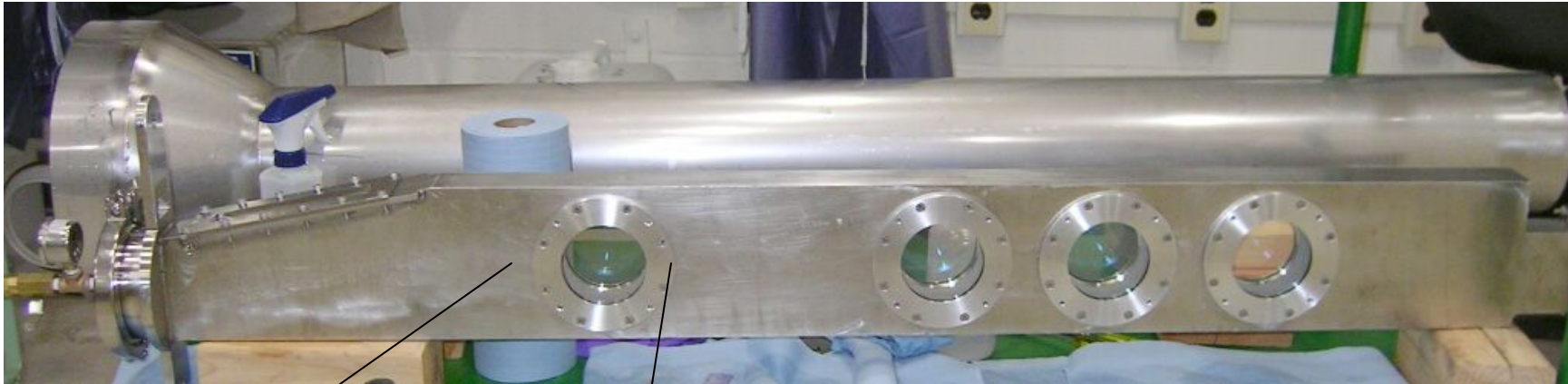


Stainless steel primary: significant leak



Sept., 28, 2006
welding defect
on the SS primary

Stainless steel primary: small leaks



10/06/06 - large leak detected, all gaskets are not good

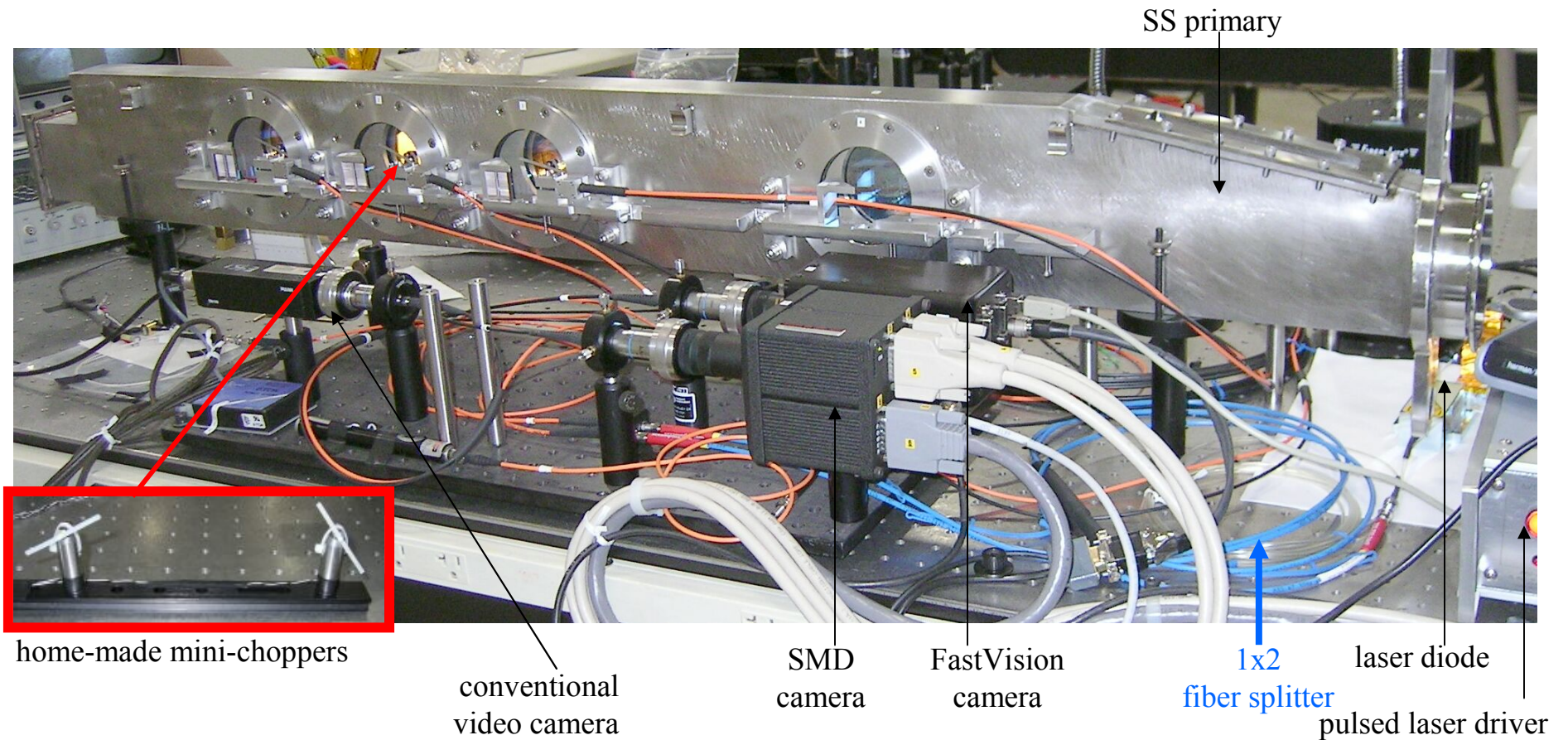
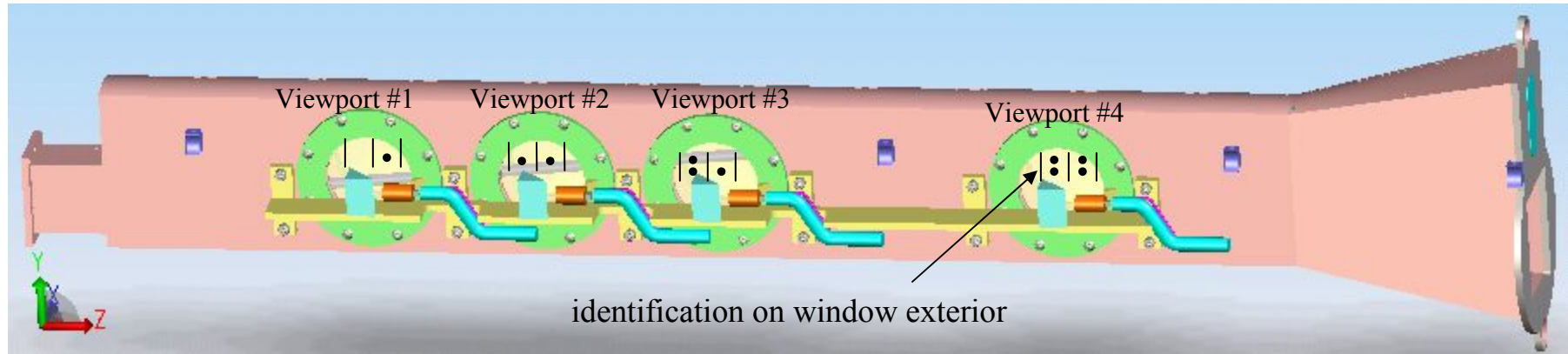
10/10/06 - new gaskets installed, small leak detected, in 17 hrs pressure drop from 21 to 8 psi, fixed viewport #4 gasket.

10/11/06 – small leak in 21 hrs pressure drops from 21 to 19 psi leak rate of ~ 1.4 mTorr/sec

10/12/06 - Leak check using Metheson 8850 flammable gas sniffer, 5 ppm sensitivity, 15 psi of Ar/Methane (90%/10%) several tap holes aren't deep enough on viewport #4, shorten a few screws and tighten the viewport.

10/13/06: **No leak detected, 21 psi holds for over 17 hrs**

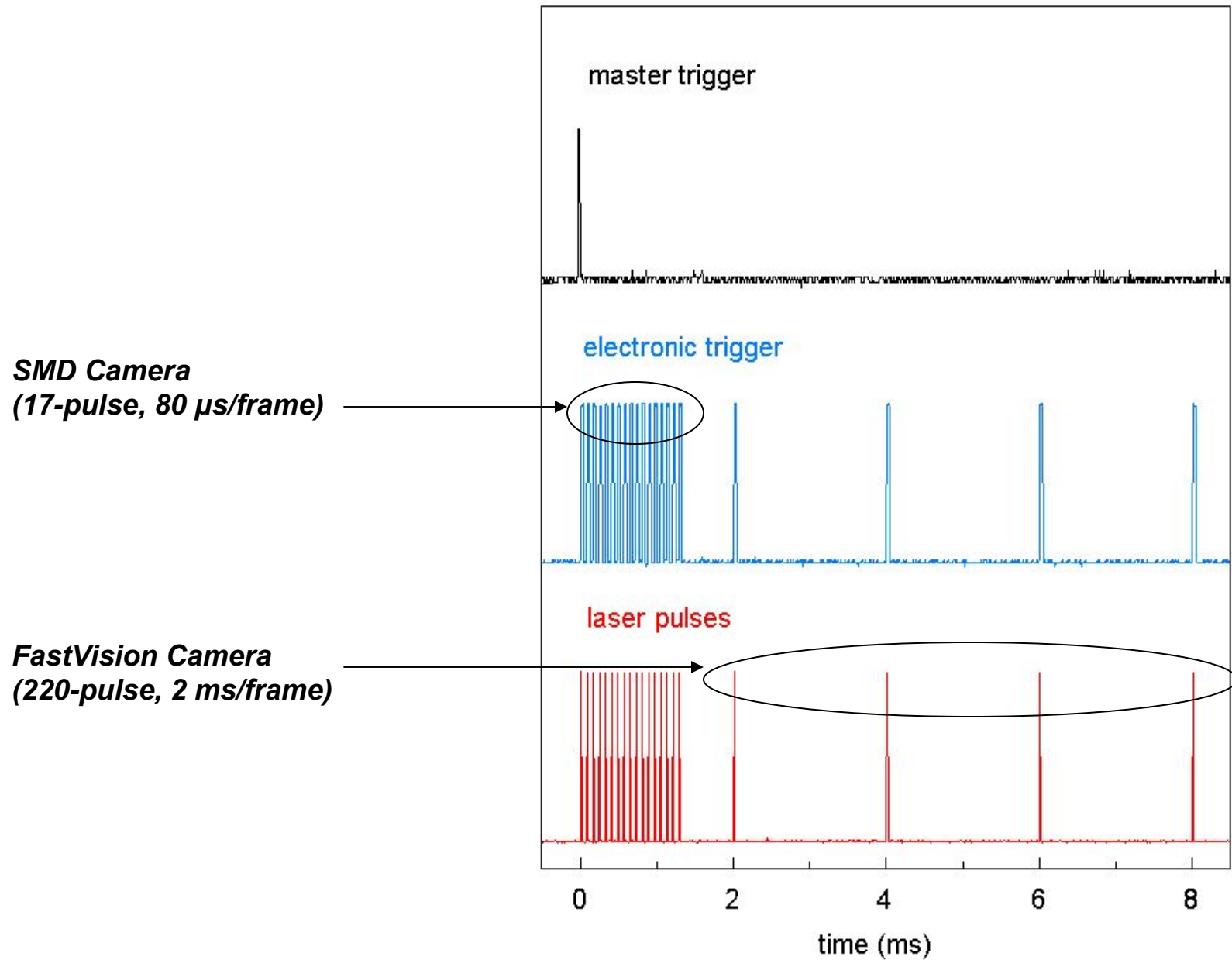
Optical Diagnostics on SS Primary



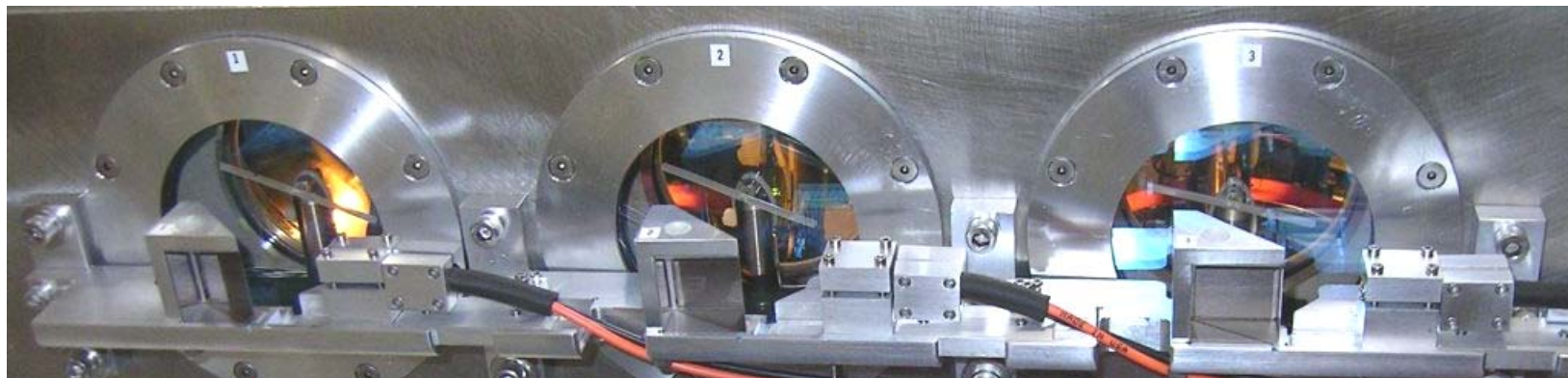
Optical Diagnostics – complete setup



Multi-Pulse Train for SMD and FastVision Cameras



Optical Diagnostics on SS Primary



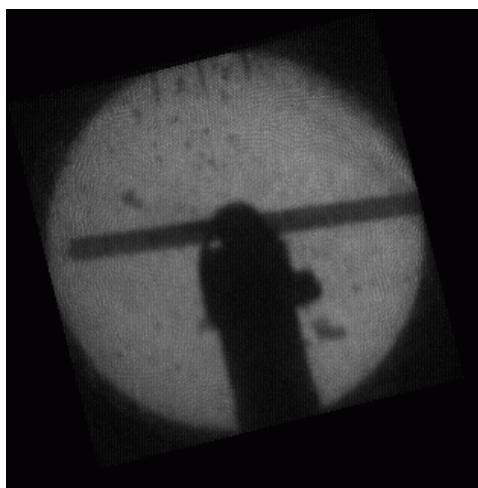
cw NIR light

conventional video camera
30 frame/sec, 1sec. movie



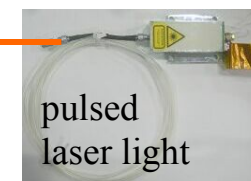
pulsed NIR light

SMD camera
80 us/frame, 16 frames



pulsed NIR light

FastVision camera
2 ms/frame, 250 frames
(only 16 frames showing)



pulsed
laser light

Summary

- two 10-meter and one 1.5 meter (temporary) long imaging fibers assembled on SS primary
- SS primary are pressure tight (20 psi)
- dynamic image collection on all viewports were tested
- dis-mount and re-mounting optical base plate requires little or no realignment
- camera ↔ viewport are inter-changeable
but the field of view on all viewports are fixed

- 3 more 10-meter imaging fibers just arrived for the remaining viewports and backup
- 2nd FastVision camera on its way for 4th viewport
- all optical diagnostic equipment headed to ORNL