TARGET AREA SYSTEMS

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Title I designs are complete for the NIF target area systems, including the final optics assembly, the target chamber, the target positioner, the target diagnostics, and the structures. The main function of the final optics assembly is to convert the 1ω light to 3ω and focus it on the target. Following a beam through the assembly, it passes through a vacuum window, the conversion crystals, the final focus lens, a diffractive optic plate, a debris shield, and a 3ω detector. The target chamber acts primarily as a vacuum chamber and provides neutron and gamma ray shielding to the target area. Target chamber systems include the vacuum chamber, neutron/gamma ray shielding, the first wall, vacuum systems, and support structures. The primary functions of the target positioner are to mount, insert, position, and maintain targets for illumination by the laser beams. The target diagnostic system provides the optical, x-ray, and nuclear diagnostics required to support the NIF experimental plan. The NIF project is responsible for locating nearly 90 detectors for 20 experiments on the vacuum chamber and for designing the diagnostic instrument manipulator and three diagnostic systems—the time-resolved x-ray imaging system, the static x-ray imaging system, and the x-ray streak slit camera. The target area structural supports provide a stable vibrational and thermal environment for the mirrors, diagnostics, target positioner, and target chamber. Components of the target area structures are mirror structures, beam tubes, guillotines, passive damping structures, and catwalks and platforms.

Introduction

The NIF target area provides the capability for conducting ICF experiments. Our preliminary design meets NIF's system requirements by integrating the target area subsystems, providing optomechanical stability, incorporating target diagnostics, managing laser light and target energies, protecting the optics, and providing radiation shielding. The target area systems must also meet demanding requirements before, during, and after a shot. The systems include the final optics assemblies, the target chamber, the target positioner, the target diagnostics, and the structures. The requirements and Title I design of each subsystem are covered in this article.

Final Optics Assembly

The final optics assembly (FOA) is the last element of the main laser system and the first of the target area systems. NIF's 192 beamlines feed into the 48 FOAs mounted to the surface of the target chamber. The FOAs have a number of design challenges. They must be mounted at eight different angles to the vertical; the optics must be carefully mounted in a very clean, temperature controlled, mechanically stable assembly to meet NIF's performance requirements; 3ω damage to optics must be mitigated; and the operational access is limited.

The optical configuration requirements result in the design shown in Figure 1. Four beams are routed from the laser bay to an FOA. The vacuum window is located in the 1ω beam to reduce the likelihood of its damage. The conversion crystals are mounted and precisely aligned to the beamline. The lens focuses the light to the target location, and a beam-smoothing phase plate is located with the debris shield for ease of changeout. In this way, the FOAs provide a vacuum barrier for the target chamber, convert 1ω to 3ω light, focus the 3ω light to target center, allow for beam smoothing, allow for 3ω power measurement, and provide a protective shield from the target debris.

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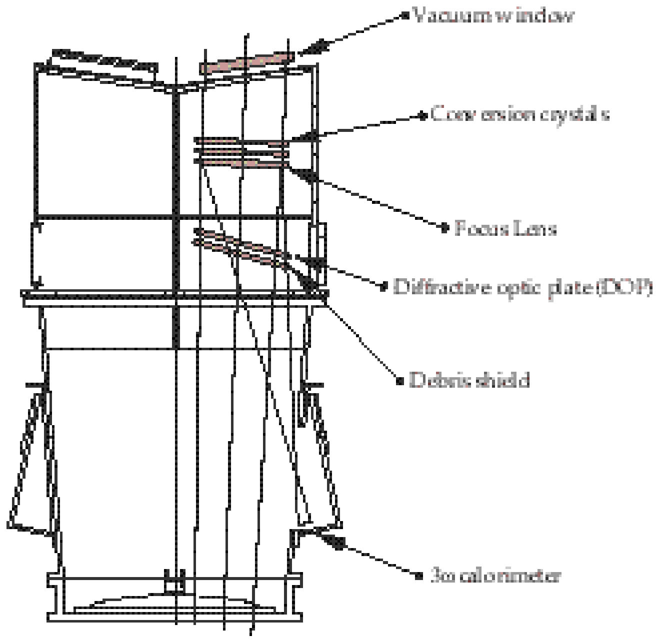

FIGURE 1. The optical design requires the final optics assembly to support a number of key optical components. (40-00-1097-2268pb01)

Figure 2 shows the integrated optomechanical design package, including the main subsystems: the integrated optics modules (IOMs), which hold the final optics cells and debris shield cassettes; the 3ω calorimeter chamber; and the vacuum isolation valve—each of which is discussed in the following paragraphs.

The IOM is the line-replaceable unit (LRU) that holds the FOA's optical elements. Each IOM 1100 mm × 670 mm × 650 mm, weighs 350 kg, and will be constructed of welded or cast aluminum. Stress and deflection calculations show this design meets stability and stress requirements.

The final optics cell (FOC) is a precision optomechanical mount. It is kinematically mounted within the IOM, and it is the final element in the optics train for aligning and diagnosing the beamline. It holds the crystals, the final focus lens, and a diffractive optic. To meet the frequency conversion efficiency requirements, the FOC must provide full-edge support to the crystals. (In past laser systems, these crystals have only been supported at the corners.) The FOC must also provide flat surfaces (less than 5 μm) for mounting the crystals and for alignment. All optics must be referenced to each other within ±10 μrad, and it is desirable that the FOC be as small as possible. The manufacture and assembly of the FOC are critical design drivers for the system. Table 1 shows the specifications for position, alignment, and resolution of the FOC. Figure 3 shows a cross section of the FOC components. The FOC adjustment system has a full range of motion for focus and for angular adjustment with respect to the beam axis. Translation of the FOC accommodates targets at locations other than at chamber center. Finely

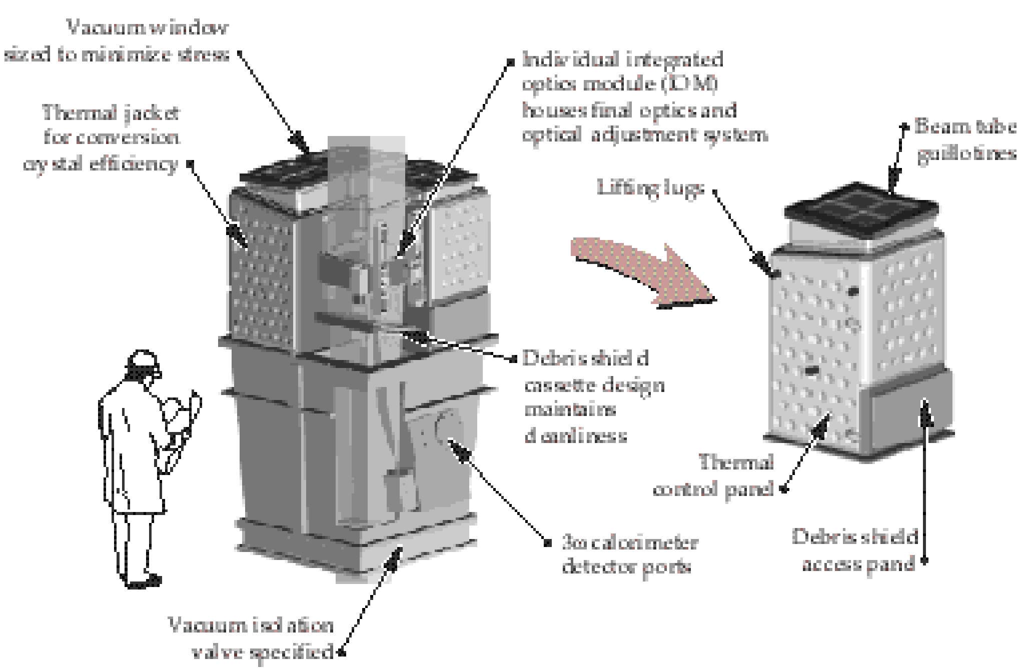

FIGURE 2. The final optics assembly is an integrated optomechanical design package. (40-00-1097-2269pb01)

TABLE 1. The specifications for position, alignment, and resolution of the final optics cell.

Mounting/position for final optics						
	±Tolerance (mm or μrad)					
Optical component	**x**	**y**	**z**	**θx**	**θy**	**θz**
Vacuum window	3	3	3	5000	5000	5000
SHG	2	2	2	20	20	5000
THG	2	2	2	20	20	5000
Final focus lens	0	0	0	0	0	5000
Diffractive optic	3	3	3	10000	10000	10000
Debris shield	3	3	3	30000	30000	30000
Alignment table for final optics						
	±Accuracy (mm or μrad)					
Optical component	x	y	z	θx	θy	θz
Final optic cell	0.1[4]	0.1[4]	0.3	5	5	n / a
	±Resolution (mm or μrad)					
Optical component	x	y	z	θx	θy	θz
Final optic cell	n / a	n / a	0.1	2	2	n / a

resolved angular motion is needed to achieve high crystal conversion efficiency.

The debris shield cassette is an LRU within the IOM LRU. This cassette is designed to be an independent unit, since all 192 cassettes must be changed weekly when NIF is operational. Within the FOA, the debris shield is tilted relative to the beamline for ghost control. The cassette contains two glass plates, the debris shield, and the diffractive optics plate.

Laser diagnostic requirements impact the FOA design in two areas. First, a 1ω-beam centering fiducial must move into and out of the beam for alignment. The fiducial mounts for the FOC must be centered with respect to the FOC aperture within 0.2 mm, or 0.05% of the beam aperture. Second, for each beamline, a 3ω power measurement requires that a 3ω sampling grating be placed on the plano surface of the final focus lens. The calorimeter detector is located off-axis. These diagnostics affect the aperture of the detector—which must be sized to accommodate a range of target locations—and the orientation of the lens. During Title I, we developed a concept for this fiducial, including an arm, mounted to the FOC, that swings ~45° into the beamline during alignment.

As shown in Figure 4, the vacuum isolation valve interfaces directly with the target chamber. This valve provides operational flexibility, allowing the debris shield

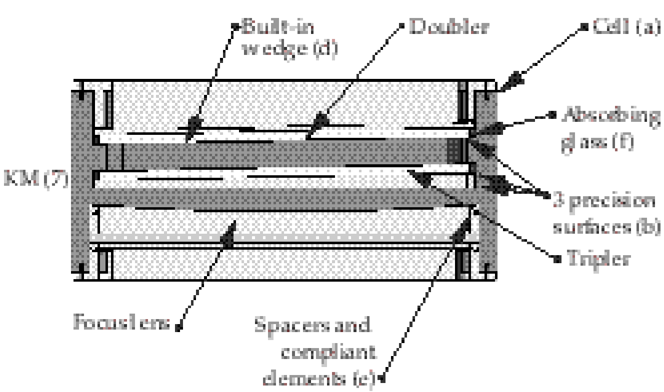

FIGURE 3. The final optics cell, includes the following features: (a) A stiff and stable one-piece cell for mounting and referencing all the optical elements. (b) Three precision surfaces for mounting the optics. (d) A built-in wedge of 10 mrad, between the lens and the crystals. (e) Spacers and compliant elements to load and hold the optics in the cell. (f) Absorbing glass, which also suppresses stimulated Raman scattering. The final optics cell will be kinematically mounted to the actuation system with three ball-and-vees. (40-00-1097-2270pb01)

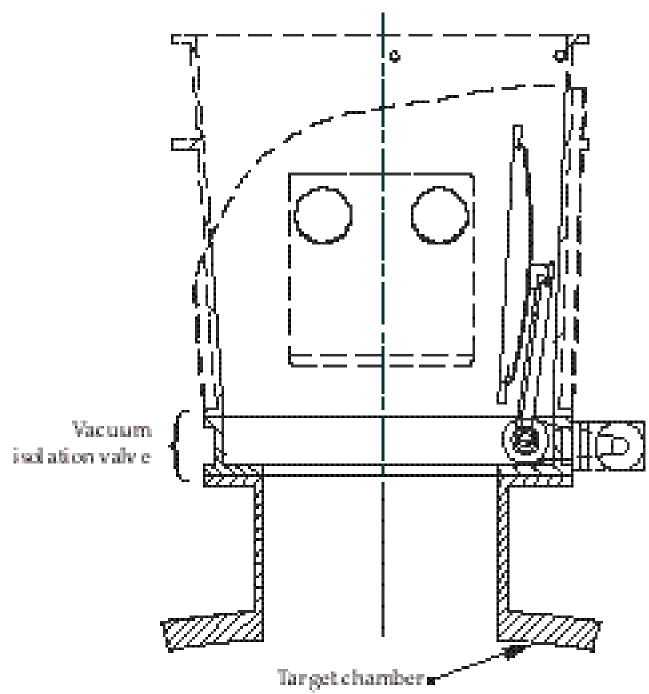

FIGURE 4. The vacuum isolation valve interfaces directly with the target chamber. (40-00-1097-2271pb01)

cassette and IOM to be removed with the chamber at vacuum. This aluminum valve is 1300 mm × 1300 mm × 205 mm, with an 800-mm-square aperture.

Title II Activities

We have a preliminary design of the FOA that accommodates the NIF design requirements. During Title II, we will complete the design of the IOM handling features, conduct a detailed analysis of the stability performance of the entire FOA, design and analyze vacuum housings to satisfy cleanliness and stress requirements, and build and test the thermal control system for the crystals. The design for the 1ω-beam centering fiducial will also be further developed and tested in a full-scale FOA prototype. This prototype will enable us to evaluate key aspects of cleanliness and operability. Our first Title II priority for the FOC is to optimize the kinematic mount locations to minimize deflections and induced stress to the cell. We will optimize the cell design based on a detailed analysis of the cell in all operational orientations and based on the details of the optics / cell interfaces.

Target Chamber

The target chamber has the following major subsystems: the vacuum chamber, the neutron / gamma ray shielding, the “first wall,” the vacuum systems, and the support structures (Figure 5).

Vacuum Chamber and Neutron/ Gamma Ray Shielding

The vacuum chamber must provide the mechanical interface between the target and the building environment, provide a vacuum environment for the target, provide mounting points and supports for the FOAs, satisfy general alignment requirements for the FOAs, and contain target debris. The vacuum chamber must maintain a 10^{-6} Torr vacuum, support DT yields totaling 1200 MJ / y, and accommodate test objects up to 2.5 m in diameter, 7 m long, and weighing up to 4500 kg. It also has to incorporate FOA and diagnostics ports, provide support for the neutron / gamma ray shielding, and be made of low activation material.

The vacuum chamber is designed to be a welded aluminum sphere, with an inner diameter of 10 m (±0.05 m) and walls nominally 10 cm thick. The chamber has 72 FOA ports, 48 of which are used at a time (the configuration depends on whether indirect- or direct-drive illumination is being done). These ports have inner diameters of 116 cm. There are also 85 diagnostic ports with inner diameters varying from 15 to 70 cm, and a 1.5-m-diam port for studying weapons effects (Figure 5). The aluminum chamber has an outer layer of borated concrete that provides neutron and gamma-ray shielding. The concrete is applied in place over steel rebar tied to the chamber.

The chamber’s design takes into account the lateral movement of the FOA due to the rise in target chamber temperature from laser and target energies after a shot. The lateral motion results in a change in the location of the focal point relative to the target building and the target positioner. We determined that the lateral motion is acceptable; for the worst FOA (which is 50° from the pole) the repeating shot sequence with a four-hour shot period results in a lateral motion of 2.5 μm in the two-hour alignment period. For an eight-hour shot period, the motion is 1.2 μm. These motions are only a small portion of the total FOA lateral motion allowed (6 μm). The target chamber temperature may require regulation to thermally control the FOAs and the target positioner.

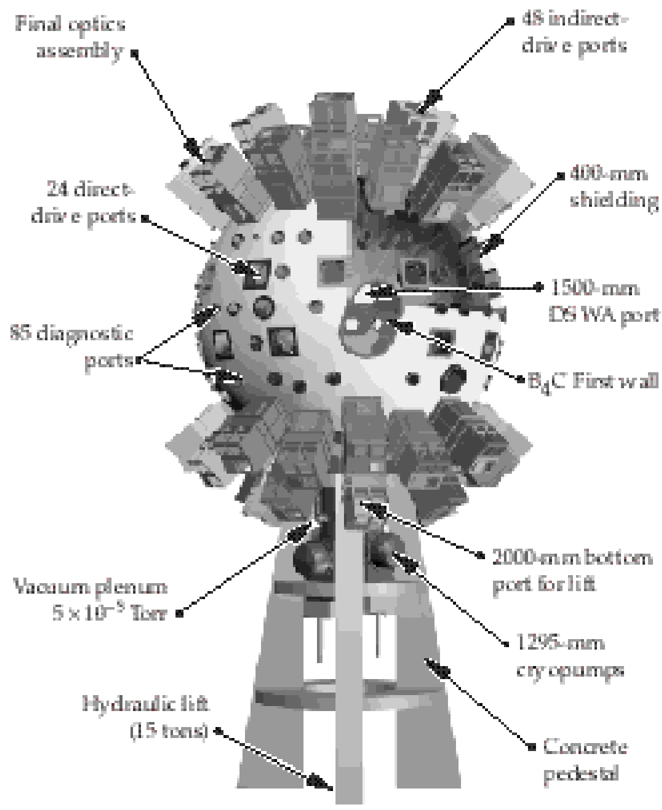

FIGURE 5. The target chamber with its ports and five major subsystems. (40-00-1096-2482pb02)

The elevated temperature has a detrimental effect on the KDP crystal temperature regulation and on the target positioner's thermal stability.

The neutron / gamma ray shielding on the chamber must limit the radiation intensity to personnel in the target building and be made from low-activation materials. The shielding design calls for 40 cm of concrete containing 1% boron to be applied to the exterior of the vacuum chamber. The exterior of the concrete will be sealed with an epoxy paint; no other protective coating is needed. The concrete shield serves a dual purpose: it reduces worker radiation exposures from the chamber and reduces neutron activation of the equipment outside the chamber. Time-motion studies indicate that, three days following a 20-MJ yield, the chamber and shield should contribute <5 mrem / h to the total dose equivalent rate. Although the vacuum chamber will be designed to carry the shield as a dead-weight load, the shield is designed to be self-supporting and to transmit its load to the pedestal. To make the shell self-supporting, three layers of 3 / 4-in.-diam steel rebar will be attached to the vacuum chamber with welded studs.

Title II Activities

During Title II, we will complete the procurement process for the chamber, detail lateral support attachments and complete their stress analysis, complete details of the plenum attachment to the chamber, evaluate the design consequences of using shielding as a structural member, complete the detail design and specification of shielding and the method of support by the pedestal, and complete the detailed design of the chamber adjusting mechanism.

First Wall and Beam Dumps

The first wall's primary function is to prevent damage to the optics due to ablation of the target chamber. There are several threats to the first wall, including x rays, shrapnel, scattered 3ω laser light, vacuum outgassing, and energetic ions and neutrons. Tests on potential materials indicate that boron carbide (B_4C) is the best overall material for the first wall. It is least removed by x rays, tolerates the scattered 3ω light and may also work as a beam dump. B_4C particles also tend to be blown off optics by laser light without inducing damage, thereby reducing the need to clean the debris shields. B_4C can be applied as a plasma spray on aluminum with low enough porosity to meet outgassing and cleaning erosion criteria.

The first wall will be a mosaic pattern of 348 panels, consisting of eight basic shapes (Figure 6); there are 240 variations on the eight basic shapes. Panels will consist of an aluminum backing plate, plasma-sprayed with B_4C. There are 1 / 4-in. gaps between panels, and the panels have square laser entrance holes. The gaps will allow for manufacturing and robot placement, but will require flashing in the forms of B_4C strips between panels.

The unconverted light absorbers, or beam dumps, must meet stringent performance requirements (Table 2).

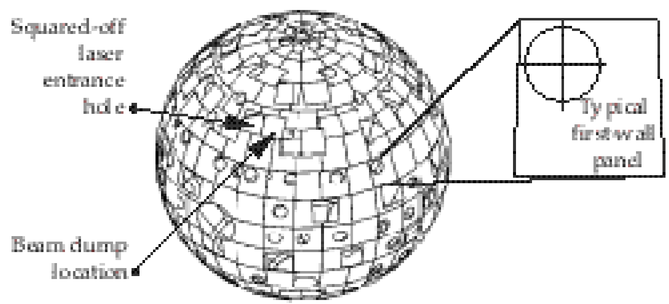

FIGURE 6. The first wall is a mosaic pattern of eight basic shapes. (40-00-1097-2274pb01)

TABLE 2. Performance requirements for unconverted light absorbers.

Area	Criteria	Set by
X-ray, 1ω and 2ω response	<0.3 g particulate and condensable mass removal from first wall for <5 MJ shot, and <2 g of mass removal for >5 MJ shot (total for first wall and beam dumps)	Debris shield laser damage
Absorbance of 1ω and 2ω light	<1% collimated light back up the beam path, 80% absorbance desired, and transmission of 0.03 J / cm^2 or less to back surface of beam dump	Ghost reflection requirements and ablation of target chamber, upstream amplifier components
3ω response	Survive full-energy 3ω shot without catastrophic failure	Life-cycle cost and secondary damage
Shrapnel response	One-year lifetime	Debris shield laser damage and life-cycle cost

The average fluence of 14 J/cm^2 on the beam dump depends on an overlap of the first- and second-order images. The 1ω contributes from 2.3 to 11.9 J/cm^2 to this fluence, and the 2ω ranges from 0.3 to 1.7 J/cm^2. The peaks, caused by beam modulation and inefficient conversion at the edges of the beam, are 40 to 50 J/cm^2 for 1ω and 12 J/cm^2 for 2ω. The baseline design for the beam dumps consists of louvered B_4C panels in boxes with Teflon film covers. There will be one beam dump for each set of four beamlines, approximately 90 cm × 90 cm, when full-beam steering is possible (Figure 7a). The louvered B_4C will be plates of boron carbide that absorb laser light. The plates will be angled at 60° to the incoming laser, and ablated material will be deposited on the backs of adjacent louvers (Figure 7b). The Teflon film cover will transmit laser light as well as contain the ablated material. These covers will be mounted on rollers to allow replacement after single shots.

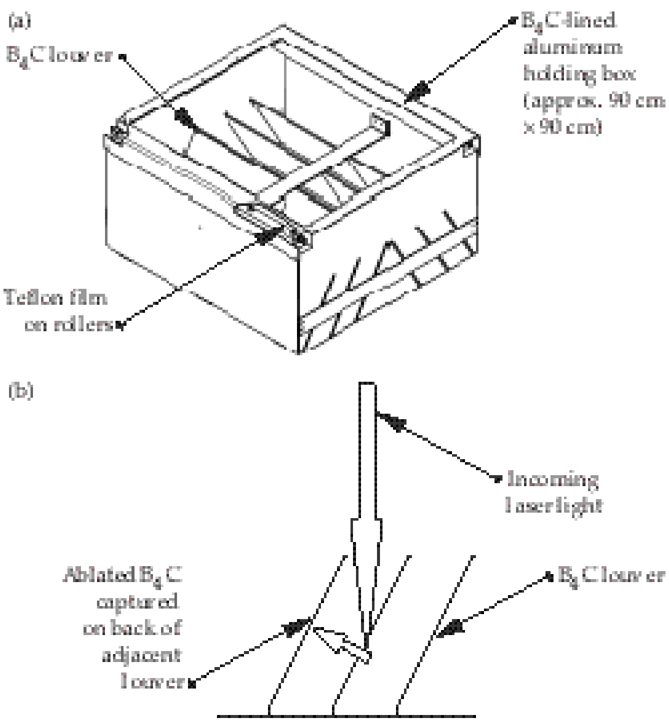

FIGURE 7. (a) Louvered B_4C concept for beam dumps. (b) Capture of ablated B_4C. (40-00-1097-2275pb01)

Title II Activities

Title II activities for the first wall include testing to determine the acceptable thickness and porosity of B_4C. We will assess the shrapnel threat, minimize the cost of plasma-sprayed B_4C while increasing its performance, and prototype a full-scale panel. For the beam dumps, we will conduct further testing to determine which design is best: B_4C louvers and Teflon film or absorbing glass. We will also prototype a beam dump assembly, possibly on Nova.

Vacuum System

The vacuum system for the target chamber performs two major functions. It evacuates the chamber to the pressure required for target shots, and it evacuates the FOAs before their isolation valves open. It must also be able to handle off-normal events, such as recovery from a ruptured cryogenic tritium-filled target. It must be capable of pumping down the chamber pressure to < 5 × 10^{-5} Torr for noncryogenic targets and < 5 × 10^{-6} Torr for cryogenic targets. It must bring the chamber from atmospheric pressure to 5 × 10^{-5} Torr in less than two hours. It must also use pumps and components to prevent oil backstreaming and minimize oil input to the tritium processing system. The vacuum system must minimize vibration input to the target chamber, and cryogenic pumps and valves must fit onto the chamber plenum.

Figure 8 shows the location of the subsystems that form the vacuum system. An oil-free roughing pump will pump 2700 L/s, using cascaded Roots blowers for pressures between 760 and 10^{-3} Torr. The final stage of the roughing pump will be located in the target bay at the –1.1-m level to minimize conductance losses. Other stages, located in a sheltered utility pad, will have pumps in parallel. Three turbodrag pumps—each capable of pumping 1500 L/s at pressures of 1 to 10^{-7} Torr—will provide intermediate pumping between the rough and high vacuum, if required. Four cryogenic pumps, a net pumping speed of 180,000 L/s of water vapor from 0.2 to 10^{-7} Torr, will be the primary high-vacuum pumps. Each pump will use 4 gal/h of liquid nitrogen. The vacuum system uses three at any one time, leaving an extra for maintenance or regeneration. The four aluminum cryogenic pump gate-valves have 48-in. apertures. Four oil-free off-normal roughing

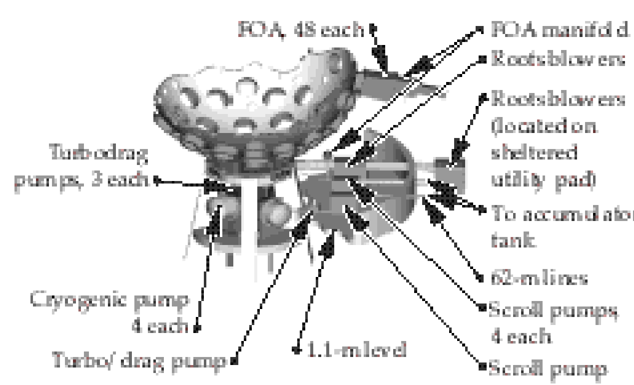

FIGURE 8. Locations of the vacuum system equipment for the target chamber. (40-00-1097-2276pb01)

pumps, each of which pumps 8 L/s from 760 to 10^{-3} Torr, will be used to evacuate the chamber, FOAs, and/or diagnostic tubes in the event that the total pressure rises to $>10^{-2}$ Torr. The four pumps are in parallel for reliability.

The subsystems also include a number of total and partial pressure gauges, including convectrons (covering the range from 760 to 10^{-3} Torr) located on the chamber, pumps and selected piping, a capacitance manometer (1000 to 0.1 Torr) located on the chamber, ionization gauges on the chamber and pumps (10^{-2} to 10^{-7} Torr), and a partial pressure analyzer (760 to 10^{-7} Torr) that provides an option to differentially pump through a variable conductance valve to the chamber. There are also scroll and turbodrag pumps in series, which help regenerate the cryopumps The gases from the regeneration cycle are sent to an accumulator tank for tritium processing. A chamber leak detection system can detect a leak rate as low as 10^{-3} atm-cc/s and can detect leaks at pressures from 1 atm to 10^{-7} Torr. There is a similar system on the FOA ports to detect leaks. The target area vacuum systems and FOA vacuum isolation valves will have real-time controls.

This vacuum system design meets the functional requirement of 5×10^{-5} Torr in two hours, with a half-hour margin. The design is governed by the use of parallel pumps to prevent single point failures. None of the pumps use oil, to avoid oil contamination of the chamber and tritium contamination of the oil. The pressure measurement sensors and locations will allow enhanced troubleshooting capability.

Title II Activities

Our Title II priorities for the vacuum system involve defining the gas loads more accurately, refining the equipment requirements and specifications, refining vacuum and venting aspects of the FOAs, and producing detailed component layout drawings as well as detailed pipe routing drawings.

Mechanical Structures

Two types of structures—the pedestal and the lateral supports—support the vacuum chamber. The pedestal must support a vertical static load of ~650 tonnes (t), remain elastic under a seismic event, provide a center opening that is at least 1.85 m in internal diameter and extends ~3 m high, and provide access where the vacuum system connects to the cryopump and turbo-pump systems. The lateral supports must provide coupling between the chamber and the passive damping system and minimize the stress on the chamber wall. Figure 9 shows the pedestal design configuration. The pedestal is made of reinforced concrete and is tied-in to the LTAB floor and support floors.

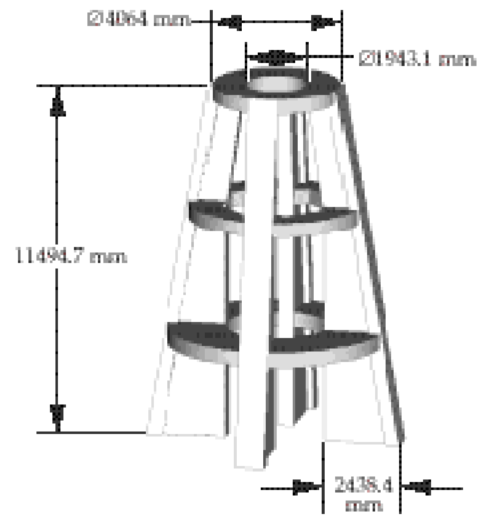

FIGURE 9. Pedestal design configuration. (40-00-1097-2277pb01)

Title II Activities

The lateral support system will be designed during Title II. We plan to complete the preliminary stress analysis by January 1997 for inclusion in the vacuum chamber wall thickness requirements, and complete the detail design by June 1997 for inclusion in the vacuum chamber manufacturing process.

Target Positioner

The primary functions of the target positioner are to mount, insert, position, and maintain targets at specified positions and within specified tolerances for illumination by the laser beams. An identical positioner is also required to mount, insert, and position the target alignment system for coordination of target positioning and laser aiming in concert with the chamber-center reference system. Table 3 shows the most significant requirements for the positioner. In brief, it must have precision location capability at the end of a very long cantilever. It must extend a target assembly (up to 50-cm diam and 200-kg mass) 6 m into the chamber, and position it with ~1-μm accuracy. It also needs to hold the assembly stable to within ±6 μm. The positioner must operate in an extreme environment that includes ultraviolet, neutron, and x-ray radiation. Figure 10 shows the overall design of the positioner. Figure 11 shows the forward boom section entering the target chamber; Figure 12 shows the boom tip, including the angular positioning mechanisms and the blast mitigation ablator (an aluminum foam disc). The boom will be made of graphite fiber-reinforced carbon (GFRC), with a diameter of 520 mm. The outer surface will have an opaque shield to provide protection from ultraviolet light. The boom will be filled with borated polyethylene to protect the regions

TABLE 3. Most significant requirements for the target positioner.

Most significant SSDRS Parameter	Requirement
Positional accuracy	6 µm
Stability (vibrational, thermal)	6 µm
Rotational resolution	1 mrad
Translational DOF	3
Rotational DOF	2
Target assembly mass	Up to 200 kg
Target assembly size	Up to 2 m long × 500 mm dia
Environment	X-ray, neutron, thermal, vacuum
Operational	Minimize adverse effects on debris shields, vacuum system

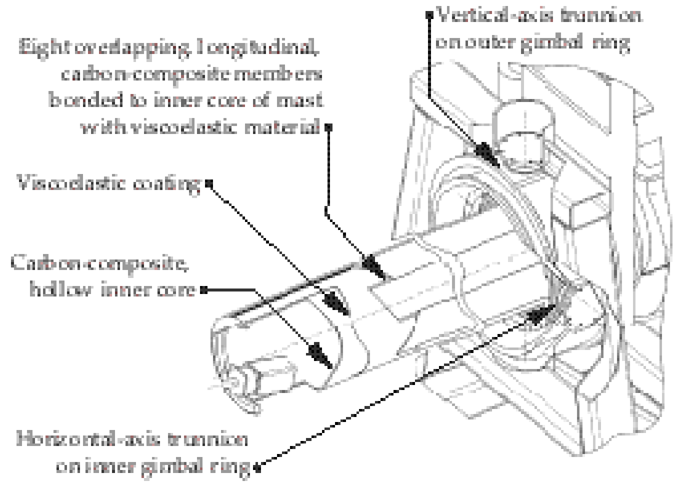

FIGURE 11. Forward boom section of the target positioner. (40-00-1097-2279pb01)

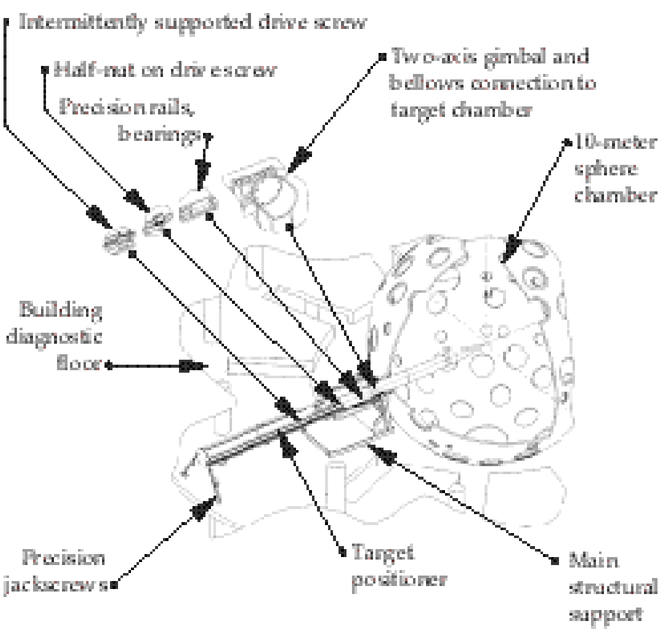

FIGURE 10. Target positioner design and components. (40-00-1097-2278pb01)

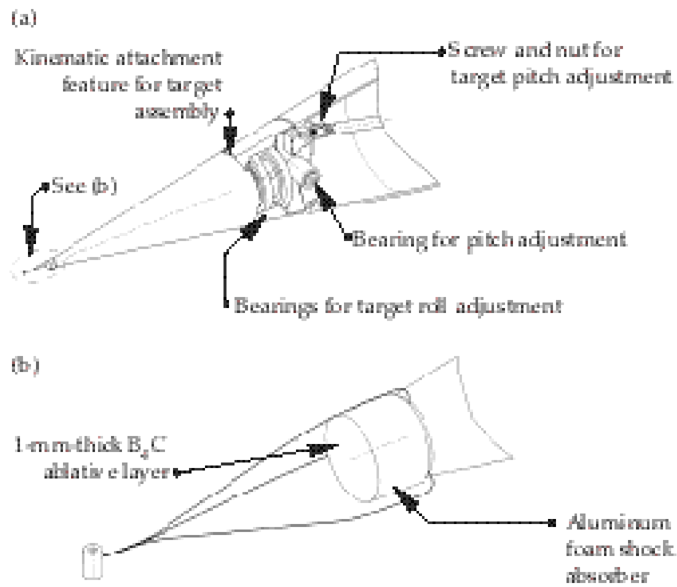

FIGURE 12. (a) Boom tip angular positioning mechanisms. (b) A typical (noncryogenic) target assembly, with a blast mitigation / ablator foam disc in place. (40-00-1097-2280pb01)

outside the positioner's open valve from neutrons. "Barrel staves" bonded by viscoelastic material to the boom will provide passive vibration damping. The design includes two-axis articulation aft of the target assembly mount for angle adjustments (Figure 13). The portion of the target assembly that is <100 mm from the target will be protected from the shock effects of cold x rays and debris by a shield consisting of a <1-mm B_4C ablative layer over an aluminum foam pad. These shields are throw-away items inserted in holders between the targets and the structure of the target assemblies.

Title II Activities

The target / target alignment sensor positioner design is fairly mature. Our Title II activities for the positioner include selecting precision components from among suitable alternatives, completing the detailed design,

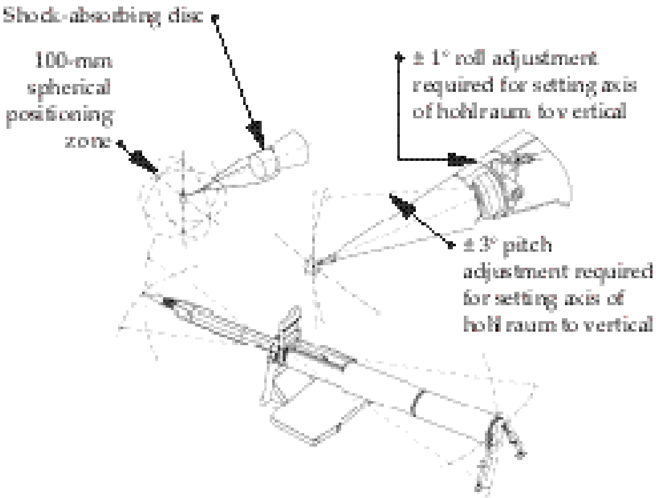

FIGURE 13. Two-axis articulation produces displacement and angulation. (40-00-1097-2281pb01)

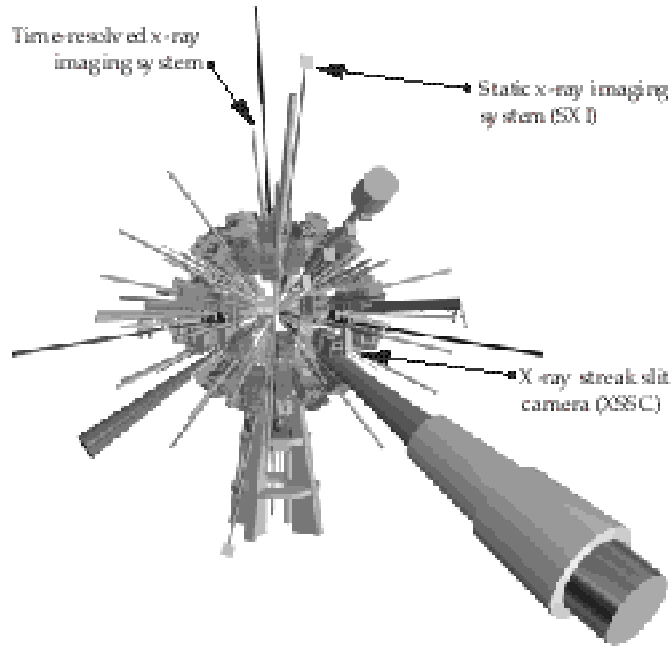

FIGURE 14. Location of diagnostics on the target chamber. (40-00-1097-2282pb01)

and designing shielding against neutrons and gamma-rays for the retracted target alignment sensor. We will also perform structural, vibration, and thermal analyses, and perform ablation shock-loading experiments on prototype shock-absorbing discs to verify behavior under a NIF-like impulse.

Target Diagnostics

The suite of target diagnostic systems includes optical, x-ray, and nuclear diagnostics required to support the NIF experimental plan. This experimental plan includes laser system performance and verification tests on target, ignition, and weapons physics experiments; radiation effects tests; and other applications and tests as required. As of Title I, there are 20 diagnostic experiments identified at 36 locations around the target chamber. Approximately 90 individual detectors will be needed for these experiments. The types of signals to be recorded and processed include images from gated imagers and streak cameras, high-speed transient signals, and single value measurements. Figure 14 shows the preliminary layout of the identified diagnostics and other components on the target chamber. See "Placing Diagnostics on the Chamber" (next page) for the general procedure used to determine the location of these instruments. In this section, we discuss the three target diagnostics whose design is part of the construction project: the time-resolved x-ray imaging system, the static x-ray imaging system, and the x-ray streak slit camera. These three diagnostics are required for the first phase of the experimental plan, laser system performance, and verification tests on target. We also describe the design for the diagnostic instrument manipulator and briefly address the other diagnostics which are not part of the NIF construction project.

The time-resolved x-ray imaging system (TRXI) provides very high frame rate images of the target. This information will initially be used to determine beam pointing, beam focusing, and spot motion performance of the laser. These functions are part of the NIF's laser system performance and verification tests. The TRXI is similar to the gated x-ray imagers (GXI and FXI) currently used on Nova. The proposed TRXI, shown in Figure 15, provides 5- to 10-μm spatial resolution, 50- to 100-ps temporal resolution, a sensitivity range to x rays with energies 3 to 10 keV, a 300- to 3000-μm field of view, a dynamic range of 100, better than

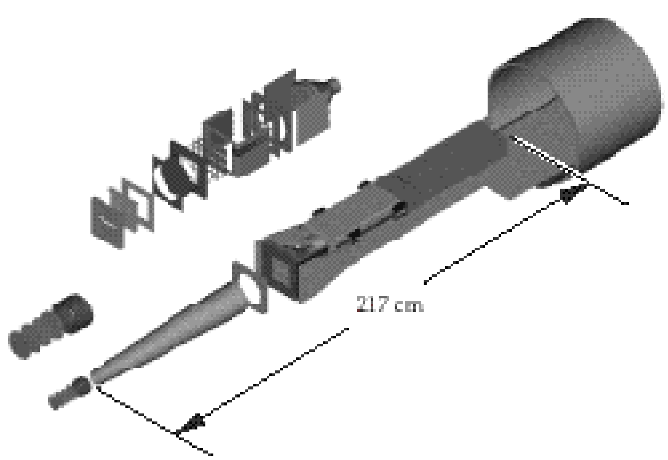

FIGURE 15. Design of the time-resolved x-ray imaging system. (40-00-1097-2283pb01)

PLACING DIAGNOSTICS ON THE CHAMBER

To determine where the nearly 90 detectors should be placed on the target chamber, we began with the layout developed for the conceptual design review. We then determined the size and position requirements for each diagnostic instrument, positioned the diagnostic on the chamber, and checked for interferences with other systems and structures. If there was a conflict, we moved the diagnostic when possible. If moving the diagnostic was not possible, we changed the structure's design. We also located extra ports, as space permitted, to accommodate possible future experiments. During this process, we had to take into account the 72 laser beam ports, the location of beam dumps on the inside of the target chamber, and the required minimum spacing between the various components mounted on the target chamber. Such components include the final optics assemblies, target positioner, target alignment system, and the diagnostic ports. Several examples of the procedure used to determine port positions follows.

Ports were usually arranged in pairs, one directly on the opposite side of the chamber from the other. This is so the opposite ports may be used for alignment purposes. The target positioner had the requirement of being located at the waist. A position halfway between two direct drive laser ports was selected. A last example is the neutron spectrometer (NS), which is a very large diagnostic. Its envelope is a cone, starting at the target chamber center. This cone is 90 cm in diameter at the target chamber wall and 40 m long. It is about 7.2 m in diameter at the end. The NS was required to angle down beneath the ground for radiation shielding purposes. The position selected puts the NS pointing down at about 26° and pointing out between the switchyard and the diagnostic building.

All in all, we have positioned 105 ports—excluding the laser beam ports—on the target chamber. This includes two for the target positioner, four for the target alignment system, one side access port for weapons effects uses, 48 assigned diagnostic ports, and 50 unassigned diagnostic ports.

50-μm alignment capability, compatibility with the diagnostic instrument manipulator, and the ability to operate in the NIF EMI / EMP and radiation environment. The proposed TRXI generates up to 30 images, with 5 images / strip for 6 strips, a magnification from 2 to 20, and continuous temporal coverage of 4.4 ns (or 733 ps / strip). The TRXI has variable gain and filtering, a charge-coupled device (CCD) readout with a film option, and computer-controlled electrical functions.

The x-ray streaked slit camera (XSSC), also required for laser system performance and verification, will make beam synchronization measurements on target. Similar to the streaked slit camera used on Nova, the XSSC is designed to produce time-resolved streak images of target emissions with energies 0.1 to 10 keV. It must have spatial resolution of 500 μm, a temporal resolution of 10 ps, and a field of view of 2 cm to diagnose the laser beam's synchronization at the target. The XSSC will also be used to measure beam smoothing, x-ray-pulse wave shape, and beam spot movement. The spatial and temporal resolutions will be upgraded for ignition and weapons physics experiments. Figure 16 shows the various components of the XSSC.

The static x-ray imager (SXI) provides time-integrated beam pointing and spot size measurements. It will operate on all shots, viewing both ends of the hohlraum. The SXI is required to produce time-integrated images of x-ray emissions with energies from 2 to 3 keV and with a spatial resolution better than 25 μm. The field of view of the SXI will be at least 1 cm. The SXI needs to be located within 20° of the chamber's poles. Figure 17 shows the basic setup for the SXI.

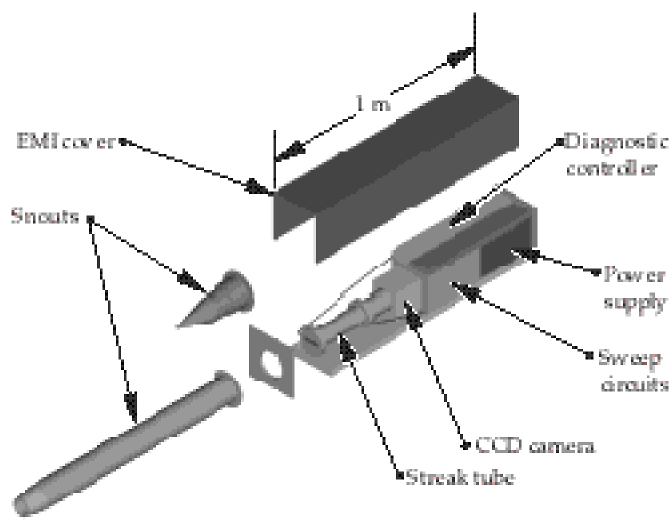

FIGURE 16. Design of the x-ray streaked slit camera. (40-00-1097-2284pb01)

The ignition and weapons physics diagnostics as of Title I are listed in Table 4. These diagnostics are not part

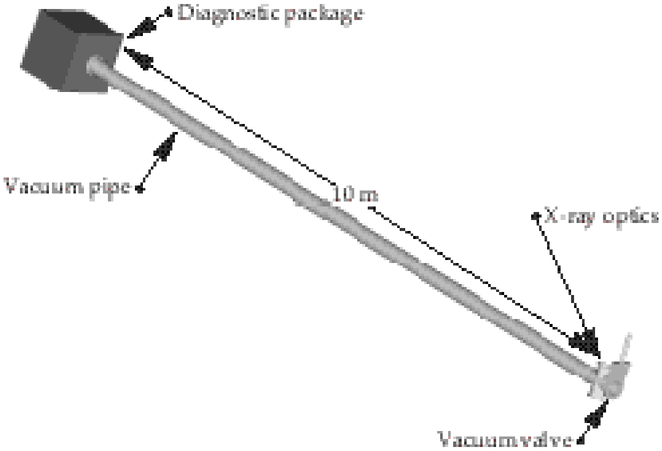

FIGURE 17. Design of the x-ray imager. (40-00-1097-2285pb01)

TABLE 4. Ignition and weapons physics diagnostics.

Soft X-Ray Imaging System (SXRI)
Soft X-Ray Power Diagnostic System (SXPD)
X-Ray Power Diagnostic (DANTE)
Passive Shock Breakout Diagnostic System (PSBO)
Active Shock Breakout Diagnostic System (ASBO)
Filter Fluorescer Diagnostic System (FFLEX)
Total Neutron Yield Diagnostic System—High (NYH)
Total Neutron Yield Diagnostic System—Low (NYL)
Neutron Time-of-Flight Diagnostic System (NTOF)
Neutron Imaging System Diagnostic System (NI)
Full Beam Laser Backscatter System (FABS)
Neutron Spectrometer Diagnostic System (NS)
Bang-Time and Burn Duration Diagnostic System (BTBD)
Neutron Coded Aperture Microscope Diagnostic System (NCAM)
Gamma Ray Spectrometer Diagnostic System (GRS)
Weapons Effects Experimental System (DSWA)

of the NIF project; however, NIF's design must allow for their installation at a later date. To fulfill this "not to preclude" requirement for these diagnostics, we collected preliminary physics performance requirements, assigned dedicated ports on the target chamber, specified stayout zones, and if required, modified the building structure to permit future installation.

Similar accommodations were made for weapons effects experiments. For these experiments, we provide a 1.5-m-diam port on the target chamber and provide capabilities to receive and transport a large diagnostic package to this port. The maximum size of this diagnostic package is set at 2.6 m high, 2.8 m wide, and 7 m long. The maximum weight is 4500 kg.

The diagnostic instrument manipulator (DIM) inserts and retracts a variety of instruments into and out of the target chamber (Figure 18). It must operate correctly when installed in any standard diameter diagnostic port and provide precision radial positioning, pointing, and alignment capabilities. The major design requirements for the DIM include a radial positioning accuracy of <±0.25 mm, a translational pointing accuracy of ±25 µm at target chamber center, and an angular pointing range capability of ±3° at the mounting point on the chamber wall. The DIM must also be able to accommodate a diagnostic package that is 300 mm in diameter, 3000 mm in length, and a maximum mass of 125 kg. The DIM must be completely retractable from the target chamber, include the appropriate utilities, and have a clear optical aperture of 100 mm through its center

The data acquisition system is part of the overall NIF Integrated Computer Control System. For a general discussion of the type of data acquisition system (DAS) used throughout NIF, see "Integrated Computer Control System" in this *Quarterly* (p. 198). The Target Diagnostic DAS has the requirement to be able to handle both unclassified and classified data. The box "Dealing with Classified Data" on facing page discusses some of the issues involved with handling classified information generated by classified target area experiments.

Title II Activities

In Title II, we will finalize design to support target diagnostics, develop a prototype of the DIM and complete designs for the TRXI, XSSC, and SXI systems.

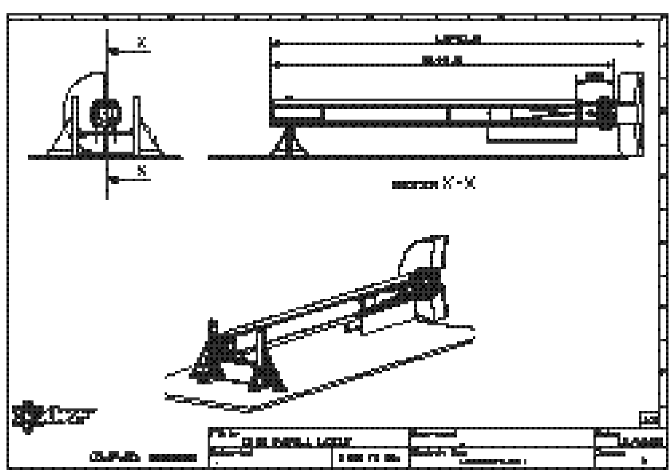

FIGURE 18. Design of the diagnostic instrument manipulator. (40-00-1097-2286pb01)

DEALING WITH CLASSIFIED DATA

The NIF is required to be able to conduct unclassified and classified experiments. The data acquisition system (DAS) for the target diagnostics is being designed to handle both types of data. The proposed design of the target diagnostics DAS has preliminary approval to handle both types of data. The following guidelines lay the foundation for the basic design. Experiments are divided into two groups: those that are always unclassified and those that are sometimes classified. The diagnostics that are always unclassified are handled with the standard method. For those diagnostics that may be classified, the DAS has a separate cable tray system that is lockable and only worked on by Q-cleared personnel. All computers will be designed with removable disk systems, and chassis will be provided with seals to indicate tampering. A special switch will be used to connect the target area DAS to either the unclassified control system or to the classified supervisory data acquisition system. Portions of the target area will be able to "swing" back and forth between an open or a limited-access area. The main classified control room is the only area in the NIF that will always be classified and the only area where classified conversations will be permitted.

Target Area Structural Supports

The target area structures provide the structural mounting and support for the mirrors, diagnostics, target positioner, and target chamber. The structures must provide structural support and vibration damping, and maintain stability for a two-hour interval after the beam alignment and before a laser shot. The structures must also provide lateral structural support to the target chamber and be constructed from low-activation materials.

We also must provide platforms and catwalks and shielding for the diagnostics. We provide thermal stability by a horizontal flow of air from the heating, ventilation, and air conditioning system (HVAC) at each floor. Vibrational stability and accessibility in the mirror rooms is provided by structural concrete floors, radial ribs, and columns. Finally, lateral supports provide passive damping and seismic restraint. Figure 19 shows the various structural supports for the target area.

Among the components of the structure are mirror structures, beam tubes, guillotines, passive damping structures, and, finally, catwalks and platforms. The design for each is briefly discussed below.

The mirror structures must support the mirror structure enclosures on kinematic mounts, provide stability to ±0.7 μrad rotation and ±0.28°C, and allow accessibility for maintenance. The structures are welded from square aluminum tubing, 6 in. on a side and 0.500 in. thick, into an open space-frame structure with mounting plates. These structures come in various sizes with different attachments for the LM6, LM7 and LM8 mirrors. Figure 20 shows a typical mirror structure with transport mirror modules.

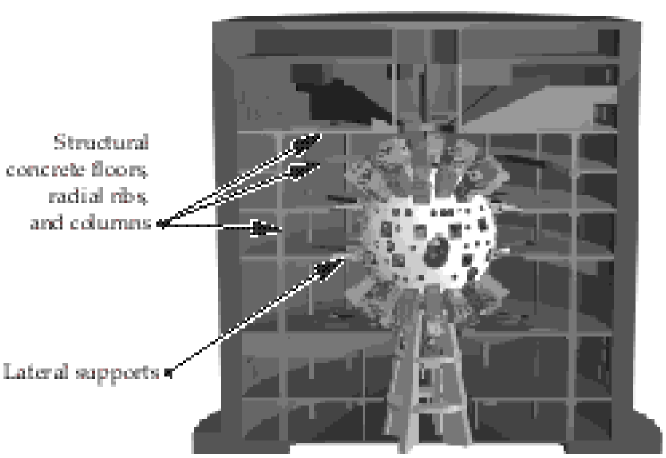

FIGURE 19. The target area structural supports.
(40-00-1097-2287pb01)

FIGURE 20. Typical mirror structure with transport mirror modules.
(40-00-1097-2288pb01)

The beam tubes must maintain argon gas at a positive pressure of 250 Pa and resist damage from stray light. The tubes must maintain a Class 100 clean-room environment, be made of low-activation materials, and provide accessibility to adjacent or attached equipment. There are three kinds of tubes: one for 1 × 1 beams, and two for 2 × 2 beams. The retractable, 1 × 1 beam tubes are located at some mirror enclosures and at FOAs. The retraction allows access for removing optics enclosures for maintenance. One variety of 2 × 2 beam tubes, used throughout the switchyard and target area, has rigid, flanged ends; the other, retractable for equipment access, is located in mirror halls on or near floors. All of the beam tubes are made of aluminum or Lexan. The rigid tubes require a flexible section for alignment and removal. Rigid tubes have aluminum end flanges and use O ring seals, and have painted external surfaces. The treatment of the internal surfaces will be decided in Title II. There is also an internal aluminum shield for 1ω light. The retractable beam tube sections have flexible outer sleeves to cover the sliding surfaces and keep them clean. Figure 21(a) shows the beam tubes located between the FOAs and the mirror room floors, and Figure 21(b) shows a 2 × 2 section connecting to a 1 × 1 section.

Guillotines cover and seal the optical surfaces during maintenance. They must seal gas pressures of 250 Pa, maintain clean-room level 50 cleanliness, and be easily removed by one person. The exposed surfaces that remain in the beam enclosure must be resistant to 1ω light. There are two types of guillotines: (1) a single-beam type for interfaces between an IOM and a beam tube as well as between a mirror enclosure and a beam tube, and (2) a 2 × 2 beam type for retractable sections near the target room wall. The 1 × 1 guillotine is made of stainless-steel removable plates and aluminum guide rails. The assembly consists of two nested sealing plates; the large plate seals off the beam tube, and the nested plate seals off the optic assembly. The nested plates are held together by a locking cam. For the 2 × 2 guillotines, a thin film of kapton covers the beam tube opening. The sealing surface is formed by an inflatable gasket pressing on this film. The kapton film is on rollers on each side of the array; the roll of film has alternating panels of solid film and panels with holes for passing the laser beams.

The passive damping structures connect the target area floors to the target chamber and provide stability and seismic restraint for the target chamber, while reducing the vibration levels to below ambient levels. There are two truss structures—one attaches to the target chamber, the second attaches to the building floors at two levels near the target chamber's waist [Figure 22(a)]. Each truss supports a "sandwich" of visco-elastic material between steel plates [Figure 22(b)].

The catwalks and platforms must support a dead load of 10 lb / ft^2 and a live load of 150 lb / ft^2. These steel structures provide access for equipment installation and maintenance, operational flow paths, and safety egress. Many levels of platforms will be required to access the FOA, diagnostics, and mirror enclosures.

Title II Activities

During Title II, we will work with the conventional facilities to refine the final design of the columns, ribs, trusses, and HVAC ducting. Other activities include optimizing the passive damping schemes, refining support structures to reduce costs, and testing a prototype guillotine. We will also perform thermal analysis for the target area building, an acoustic vibration analysis, and a total vibration analysis at mirror locations.

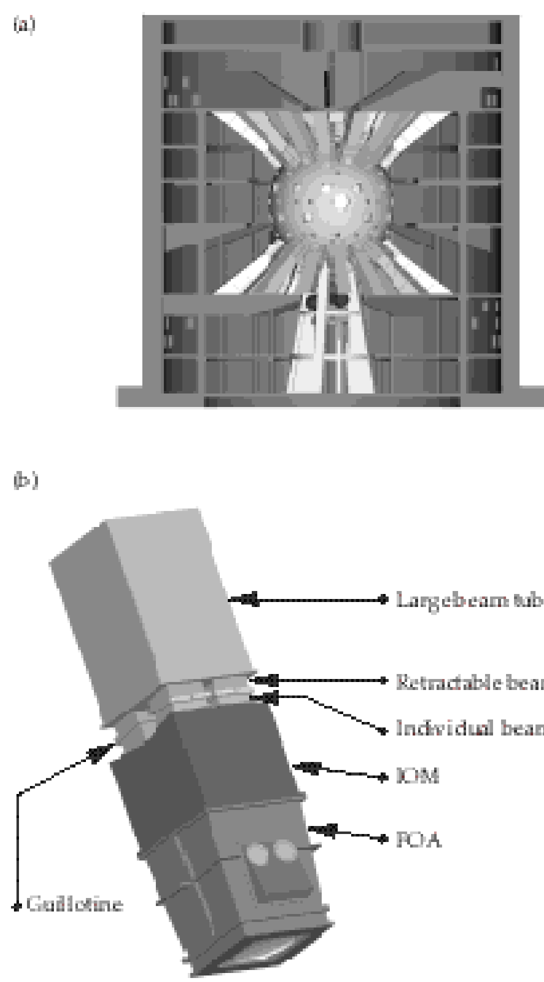

FIGURE 21. (a) Beam tube location between the FOAs and the mirror room floors. (b) A 2 × 2 section connecting to a retractable 1 × 1 section. (40-00-1097-2289pb01)

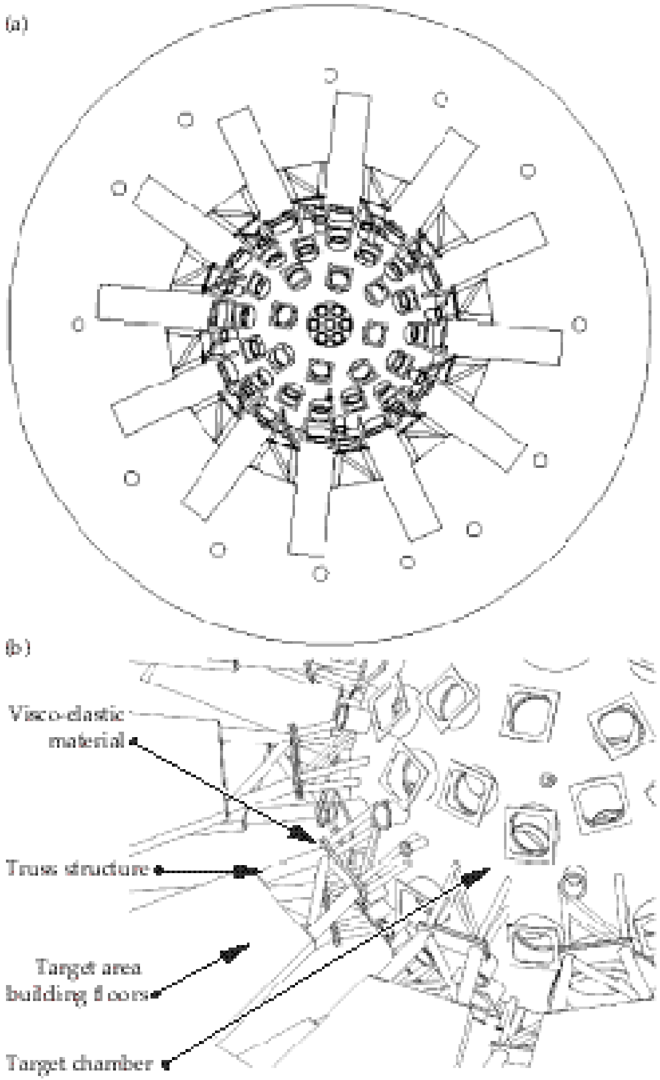

FIGURE 22. (a) The passive damping structures connect the target area building to the floors of the target chamber, a view from the top of the chamber. (b) Truss structures support a sandwich of steel plates and visco-elastic material. (40-00-1097-2290pb01)

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