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MASTER

NOVETTE CHAIN DESIGN AND PERFORMANCE

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Pulse Length:	100 ps to 5 ns
Energy Per Arm:	10-15 kJ (1.05 μ m)
	7-10 kJ (0.53 μ m)
Design Fluence:	Per Nova
Power Conditioning:	Per Nova
Laser Glass:	Phosphate
Target Shots Start:	July, 1982

NOVETTE DESIGN CONSIDERATIONS

Staging

The Novette laser system consists of two Nova phosphate glass laser chains. Figure 1 shows an optical schematic of the Novette/Nova chain. This chain consists of a driver section, which terminates at 208 mm amplifier aperture, followed by 315 mm and 460 mm diameter clear aperture output amplifier stages. The driver section contains primarily Shiva hardware with the amplifiers retrofitted with phosphate glass. The high energy needed to drive the larger Nova amplifiers requires the addition of two 208 mm "box" amplifiers to the Shiva driver chain. The 315 mm and 460 mm aperture output amplifiers are of box geometry each containing two disks. There will be total of 8 disks in the 315 mm stage and 6 disks in the 460 mm stage. Space is provided such that one additional amplifier at each diameter could be added should a future upgrade be desirable. Following the last amplifier stage the beam will be expanded to 740 mm diameter. Two mirrors are required in one arm and three mirrors in the other to direct the output beam through the Potassium Di Hydrogen Phosphate (KDP) doubling crystals to the target focusing optics.

The Nova chains require a single fold at the output of the 208 mm/315 mm spatial filter. The length of the 381 High Bay building requires that the Novette chain have an additional fold at the output of the 91.7 mm/150 mm spatial filter. Both chains will be driven by a common oscillator/preamplifier section as in Shiva. Present plans are to terminate the oscillator/preamplifier with 50 mm diameter rods to provide a nominal output energy of 10 joules. The

master oscillators and the preamplifier stages will be housed in a side lab of the 381 High Bay. The beam will be transported into the main laser bay from this side lab with a spatial filter relay element.

The Novette chains will be spatially filtered and fully relayed. The object plane of the relay will be a hard aperture placed at the entrance to each chain with successive image planes occurring near the input lens of each spatial filter/relay element and beyond the first turning mirror in the target bay. Table 1 summarizes the spatial filter parameters for the Novette baseline chain. The pinhole diameters are chosen so that the beam intensity on the pinhole edges does not exceed 10^{11} W/cm² for nominal 10 terawatt per chain, 1 ns performance. Pulses shorter than 1 ns can create larger intensities but will propagate through the pinhole before closure. For longer pulses the chain B values decrease thereby reducing the pinhole loading. The calculation of pinhole sizes of course depend upon the noise model used. In our calculation we used a model that gives good agreement with the noise spectra observed for the Argus and Shiva lasers.

GLASS PROPERTIES

Choice of phosphate glass for Nova was predicated upon the following considerations: 1) low nonlinear index-of-refraction; 2) high gain; 3) saturation fluence parameters competitive with silicate glasses; 4) proven performance in laser systems; and 5) reasonable cost. Listed in Table 2 are some important physical properties of this glass, along with properties of ED-2 silicate glass used extensively in previous systems.

Shown here are the lasing wavelength, λ ; cross-section for stimulated emission, σ_p ; fluorescence lifetime, τ ; linewidth, $\Delta\nu$; linear index-of-refraction, n_0 ; nonlinear index-of-refraction, n_2 ; and saturation fluence, E_s . The saturation fluence E_s shown in Table 2 corresponds to a value for which the output fluence from the test sample was 5 J/cm².

Recent experiments have shown that the saturation fluence is dependent upon the fluence level. Figure 2 illustrates this for LHG-8 glass. The saturation values shown in Table 2 are a valid

comparison since all test samples were pumped to approximately the same small signal and net gains. From our data, we conclude that the saturation properties of phosphate glasses are superior to ED-2-type silicate glasses over the range of fluences of interest for Nova. We account for the variation of E_s with fluence in our system performance calculations.

The specifications on the bulk properties of production phosphate glass are:

Attenuation (cm^{-1}) ≤ 0.0015

Homogeneity = $\pm 1 \times 10^{-6}$

Damage Fluence (J/cm^2) ≥ 35 .

The damage fluence quoted above is relative to the beam in air, actual fluence in a tilted disk is reduced by the index of refraction.

AMPLIFIER DESIGN

A new more efficient box amplifier design has been adopted for the 208, 315, and 460 mm aperture disks. The 315 and 208 mm designs are scaled in size from the 340 mm prototype amplifier that has been experimentally evaluated. Both the 315 and 208 mm heads use standard Shiva lamps (112 cm arc length) mounted longitudinally with respect to the axis of the amplifier. The 460 mm head uses short (48 cm arc length) lamps similar to those used on the Shiva rod amplifiers. They are mounted transverse to the axis of the amplifier. To suppress parasitic oscillation the disks in the 460 mm amplifier are split perpendicular to their long axis. In other aspects the design of the 460 mm head is similar to the 315 mm head.

Table 3 shows some important design characteristics of the 315 and 460 mm amplifiers.

FREQUENCY CONVERSION

The $0.53\mu\text{m}$ target irradiating beam will be generated at a position between the last turning mirror and the target focusing optics by passing the 74 cm beam through an array of KDP frequency doubling crystals. The Fresnel reflection losses from the crystals will be minimized by placing them between two antireflection (AR) coated windows which are index-matched to the KDP crystal material with a fluid. The individual crystals of the array will be precision cut to the appropriate phase matching angle by computer controlled diamond turning techniques. This accurate finishing of the crystals in

concert with their initial precision alignment in the array will obviate the need for individual segment adjustments. After assembly the array will perform as a single monolithic crystal. The crystal thickness has been chosen to optimize 2ω energy conversion efficiency over the anticipated operating range of the system.

Specifications for the doubling array are given in Table 4.

FLUENCE LIMITATIONS: $1.05\mu\text{m}$

Performance of Novette, as with our other glass laser systems, is limited by the threat of beam induced damage to optical components. In present systems, the greatest threat has been to AR coatings on the input lenses of spatial filters and on the target focusing optics. To achieve higher performance with Novette, we will increase the damage resistance of the spatial filter input lenses by using uncoated optics. The reduction in beam intensity resulting from the geometrical beam expansion and the reduction in beam noise modulation by the spatial filter (SF) element greatly reduces the peak fluence at the SF exit lenses. This permits use of AR coatings on the SF exit lenses and target focusing optics with a minimal risk of beam induced damage. Coated polarizers and high reflection surfaces typically have higher damage thresholds at $1.05\mu\text{m}$ than AR coated surfaces and therefore, do not limit the performance of the current Novette design. Bulk damage thresholds are not anticipated to be a threat.

To assess the threat of surface damage and to develop guidelines for Novette chain design, we adopted the following rules generated by the Nova team from available damage data.

- 1) Bulk glass damage and damage to high reflection (HR) coatings are presently not limiting performance.
- 2) For 1 ns pulses, uncoated surfaces damage at a median fluence of 16 J/cm^2 , with 70% of the surfaces tested damaging between $14\text{--}19 \text{ J/cm}^2$. At other pulse lengths (0.1 to 3 ns) uncoated surface damage appears to follow a $\sqrt{\tau}$ dependence.
- 3) Antireflection surfaces damage at 1 nsec at a median fluence of 5 J/cm^2 with 80% of the surfaces tested damaging between $4\text{--}7 \text{ J/cm}^2$. In addition, their damage threshold appears to increase slightly between 1 and 3 ns and appears to scale as $\sqrt{\tau}$ for pulses shorter than 1 ns.

- 4) There is a reasonable expectation that damage thresholds will increase. This expectation is based upon recent progress with graded-index AR surfaces, super polish AR coatings and laser polishing of uncoated surfaces.

With these guidelines the Nova team established three fluence groups for which to target the Nova 1.05 μ m design. These groups are referred to as the "A", "B", and "C" fluence groups. Table 5 shows the thresholds for coated and uncoated surfaces in each group. The thresholds in the "A" group represent the median values obtainable today. More specifically, the 1 ns values are the median values obtained by examining a large number of data taken at this pulse length. Values at other pulse lengths are then determined using rules 2 and 3 above. Thresholds shown for the "B" group represent the highest values obtainable from today's production coatings and surfaces. Again, values at other pulse durations are scaled from the 1 ns data. The "C" values represent an estimate of what may be possible in the future if one or more of several advanced approaches can be brought to production. Presently, graded-index surfaces look the most promising, with both Schott and Hoya mounting a significant development effort. Less developed are the techniques of laser polishing and super-polishing of substrate surfaces. Research samples have shown that a significant increase in damage threshold of a bare surface can be obtained by simply "burnishing" the surface with a directed CO₂ laser beam. In the case of super polish in which the substrate is finished with a bowl-feed process, there is evidence that damage thresholds for AR coatings applied to such surfaces are increased. (Both laser and super polish techniques are presently in a very elemental state and hence should be viewed as a "long shot".) Optics in the initial Novette procurements will mostly be finished and coated using present technology and will restrict initial operating levels to those obtainable with "A" fluences.

Perhaps our greatest short-term hope is for graded index parts suitable for damage free laser operation at the "B" fluence levels.

FLUENCE LIMITATIONS: 0.53 μ m

The 74 cm aperture optical train required to generate and transport the 0.53 μ m beam to the target focusing optics is shown in Figure 1. Although the threat of damage to these optical elements is not inordinately high, it is still a matter of concern. (Recent 1 ns measurements indicate that the 0.53 μ m

and $1.05\mu\text{m}$ damage thresholds are comparable (see Table 6.) In accordance with our previous discussion, we have assigned "A" and "B" fluence levels at 0.53 m according to the "rules" discussed earlier; i.e., "A" fluence is the median values obtainable today and the "B" group represents the highest values obtainable from today's production coatings. Table 7 gives the "A" and "B" fluence levels at $0.53\mu\text{m}$.

NOVETTE TARGET IRRADIATION GEOMETRY

The primary mission of Novette is to perform $0.53\mu\text{m}$ target experiments for direct comparison with those conducted at $1\mu\text{m}$ on Shiva. Ultimately this will require a 74 cm focusing system with an f -number of 1.5 or less. Unfortunately, conventional lenses of this speed limit performance due to intensification of flux on the exit surface of the lens, while an advanced all reflecting system cannot be fabricated in time for the July, 1982 target shot. An intermediate $f/2$ focusing system using Nova beam diagnostic lenses has been chosen for the baseline. This choice was made because the f -number is near that desired, the lenses are now in fabrication, and the damage-limited performance is superior to the $f/1.5$ lenses. A decision regarding use of an all reflecting system will be made later.

An all reflecting focusing system, such as the axicon shown in Figure 3, is viewed as the best candidate for the advanced system. This type of all reflecting system has the benefit of being free of chromatic aberration and avoids the absorption and nonlinear propagation effects inherent in transmitting optics. Another advantage of the axicon is the reduction in the damage threat that comes from reduced beam fluence and the higher damage thresholds of reflective coating. Since present specifications require a focal accuracy of 20 microradians, not the 0.4 microradian tolerance of a $0.53\mu\text{m}$ diffraction limited system, fabrication will be difficult but is within the present state of the art.

An $f/1.5$ clamshell "back-up" option is shown in Figure 4. It is less desirable but meets the $f/1.5$ specification using a combination of spherical "clamshell" mirrors and an $f/3$ aspheric lens (or corrector plate). In this scheme a different refractive element would probably be required for each wavelength and protection of the mirror from target debris presents a serious operating problem.

However, this option is under consideration because relative to the axicon it has a greatly reduced cost and less technical risk. In summary, the baseline design uses Nova f/2 beam diagnostic lenses for initial activation (see Table 8 for further specifications). If practical, an all reflecting system will be installed later; if not, the "back-up" f/1.5 "clamshell" could be used to provide the required fast target focusing.

NOVETTE LASER PERFORMANCE

The physical characteristics (i.e., diameter, thickness, linear and nonlinear refractive indices, and the small signal gain) of the Novette optical elements are listed in Table 9.

With these component parameters, we used the MALAPROP computer code to simulate the performance of the baseline chain. Figures 5-7 summarize the results of these calculations in graphic and tabular form. The summary includes the beam energy, the peak energy density, the mean energy density, and the ratio of the peak to mean energy densities of the beam at the entrance and exit lenses of the spatial filters and the interstage B values between spatial filter pinholes. For "A" fluences, damage to AR coated optics at either the exit lenses of the large aperture spatial filters or the focusing optics limits the chain performance. Since both the peak and mean fluences steadily increase with increasing beam diameter, all other optical elements of the chain are well below their damage threshold. At these conservative "A" damage fluences, each beam can provide eight terawatts during short pulse ($\tau \leq 1$ ns) operation and 10.5 kilojoules during longer pulse (3-5 ns) operation.

At "B" fluences each beam can provide 0.4 terawatts during short pulse operation. In this case the damage threat shifts from the coated optics to the uncoated entrance lenses of the final two spatial filters. At this high power level the system is primarily limited by the large peak to average beam modulation introduced by nonlinear self-focusing. At "B" fluences with long pulses ($\tau \geq 3$ ns) the chain is limited by gain saturation and energy storage as much as by damage threats. The amplification stages prior to the 460 mm stage must be driven into deep saturation to obtain the required drive for

the 460 mm heads. In this regime the exit lenses of the final two spatial filters and the target focusing optics all experience about the same damage threat. At "B" fluences in the long pulse regime each chain can deliver 13.5 kJ to the target.

The large number of components subject to damage risk at "B" fluences for long pulse durations prompted us to investigate a more conservative chain staging. Figures 8-10 compare the code calculations for a chain with an additional 460 mm amplifier to the baseline. Although the performance with the additional amplifier is slightly degraded at 1 ns, down to 8.75 terawatts per beam from 9.4 terawatts, long pulse performance improves and the damage threat is substantially reduced.

We projected the frequency doubled performance ($0.53\mu\text{m}$) from the $1.05\mu\text{m}$ performance with the aid of two additional computer codes: ENERG-2 ω and X-GAP. The code ENERG-2 ω calculates energy conversion efficiency and was used to optimize the KDP doubling crystal thickness for the operating range of the system. These optimization calculations assumed that the overall beam divergence and crystal alignment errors did not exceed 100 microradians. Figure 11 shows the conversion efficiency of the optimum (18 mm) thickness crystal. After establishing the conversion efficiency, we estimated the energy on target by reducing the $0.53\mu\text{m}$ beam energy exiting the crystal by the following transmission losses:

Beam Dump = 0.95

Diagnostic Beam Splitter = 0.95

Focusing Optics = 0.93

X-GAP and MALAPROP code calculations predicted any additional beam modulation caused by diffraction from the crystal interstices and its subsequent growth through the optical train from the crystal to the target focusing optics.

Figure 12 is a summary of the performance calculations and shows the operating envelope (i.e., energy deliverable to a target vs. pulse length) for the baseline chain. Curves are shown for both "A" and "B" fluences for $1.05\mu\text{m}$ and $0.53\mu\text{m}$ beams. The cross hatched regions denote the 100 microradian

uncertainty in the frequency doubled phase matching condition. Each frequency doubled beam can provide between 5 and 7.5 terawatts for short pulses and 6 to 10 kilojoules of energy for a pulse duration of 1 to 3 nanoseconds. For 3 to 5 nanosecond pulses, the 1.05 μ m beam intensity at the crystal is less than optimum reducing the 0.53 μ m beam energy to 6-8 kilojoules. Finally, Figure 13 summarizes the system performance with an additional 460 nm amplifier. This staging produces higher 1.05 μ m beam intensities at the crystal for pulse durations between 3 and 5 ns. The improved frequency doubling conversion efficiency in this case would produce about one additional kilojoule per arm of 0.53 μ m light in the 3-5 nanosecond regime.

In summary, a baseline design for the two-arm Novette system has been developed to provide target irradiation at fundamental and second harmonic wavelengths. The initial system performance is predicated on operating at "A" fluence levels with capability of providing output commensurate with "B" fluences if appropriate large aperture optics can be obtained. At the "A" fluences and the fundamental wavelength, it can deliver on target 10 to 15 terawatts of peak power for short (≤ 1 ns) pulses, and 15 to 20 kilojoules of energy for longer 3-5 ns pulses. Second harmonic power and energy on target are typically 80-85% of these levels. The maximum fluences associated with these performance projections are within "A" fluence damage levels at the respective wavelengths, indicating that routine target irradiation at these powers and energies are possible with minimal damage risk to critical large aperture optics.

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NOVETTE OPTICAL SCHEMATIC

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Fig. 1

Table 1: Novette Chair Spatial Filter/Relay Parameters

<u>Filter Relay</u>	<u>f-Number</u>	<u>Pinhole Diameter (mm)</u>	<u>Angular Acceptance</u>
			<u>Aperture (μrad)</u>
460 mm/740 mm	20	2.3	250
315 mm/460 mm	16.5	1.25	240
208 mm/315 mm	20	1.0	240
150 mm/208 mm	20.8	0.8	257
91.7 mm/150 mm	10.6	0.3	308
37.5 mm/91.7 mm	22.9	0.64	745
27 mm/37.5 mm	72	1.9	873

MEASURED SATURATION FLUX OF LHG-8 PHOSPHATE

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Fig. 2

Table 3: Phosphate Amplifier Designs

<u>Clear Aperture</u>	<u>315 mm</u>	<u>460 mm</u>
Thickness	43 mm	43 mm
Disks Per Module	2	2 (split)
SS Gain Per Module	1.78	1.93
Gain Coefficient	5.6	6.2
Energy Density	260 J/L	290 J/L
Glass Volume Per Module	14 L	28 L
Bank Energy Per Module	375 kJ	600 kJ
α_D	3.5	3.2

Table 4: Crystal Doubling Assembly Specifications

Crystals

• Material:	KDP (Potassium Dihydrogen Phosphate)
• Type of Cut:	Type II ($\theta_m = 59.23^\circ$)
• Geometrical Shape:	Square Parallelepiped
• Array I	
Total Number of Crystals:	25 + 5 Spares
Length:	150 mm $\pm$.01
Width:	150 mm $\pm$.01
Thickness	18 mm $\pm$.01
• Spacing Between Adjacent Crystals:	25 to 100 μ m
Finishing Tolerance:	$\pm$ 60 μ rad from Optimum Phase Matching Angle
	$\pm$ 1 mrad in Other Principal Axis Directions
• Array II	
Total Number of Crystals:	9 + 3 Spares
Length:	260 mm $\pm$.01
Width:	260 mm $\pm$.01
Thickness:	18 mm $\pm$.01
Spacing Between Adjacent Crystals:	25 to 100 μ m
Finishing Tolerance:	$\pm$ 60 μ rad from Optimum Phase Matching
	$\pm$ 0.5 mrad in Other Principal Axis Directions

Table 4: Crystal Doubling Assembly Specifications - (Cont'd)

Windows

Material:	BK-7
Clear Aperture Diameter:	800 mm
Thickness:	70 mm - 100 mm
AR Coating:	Exterior Window Surfaces will be finished with conventional AR coating (both 1.05 μ m and 0.53 μ m)

Index-Matching-Fluid

Material:	Poly-Chloro-Trifluoroethylene (Halocarbon Oil #56)
Layer Thickness:	4-10 μ m

NOVA DESIGN FLUENCE LEVELS (J/cm²)

	Antireflection			Uncoated		
	100 ps	1 ns	3 ns	100 ps	1 ns	3 ns
"A"	1.6*	5*	5.5*	5.1*	16*	28*
"B"	2.5**	8**	8.5**	6**	19**	33**
"C"	3.8++	12++	12.6++	11+++	35+++	61+++

* Median damage threshold for today's surfaces

** Damage threshold for best of today's surfaces

++ Super polish

+++ Laser polish/graded index

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Table 5

LASER DAMAGE THRESHOLDS OF PRODUCTION OPTICAL COMPONENTS (1 ns)

Surface type	Damage threshold, J/cm ²	
	1.05 μm	0.53 μm
Thin film, AR	4-7	3-6
Thin film, HR	6-10	2-6
Beam dump (separate wave lengths)	--	2-8
Bare polished glass	14-18	18
Gradient index	10-14	11-13

Table 7: Novette 0.53 μ m Design Fluence Levels

	<u>Antireflection</u>		<u>High Reflection</u>		<u>Uncoated</u>	
	1 ns	3 ns	1 ns	3 ns	1 ns	3 ns
"A" J/cm ²	4.5	4.5	4.5	4.5	16	28
"B" J/cm ²	6	6	6	6	19	33

NOVETTE f/1.5, 800 mm ϕ AXICON FOCUSING OPTICS

Notes:

1. Cross section of inner cone is a 90° - 45° - 45° triangle
2. Cross section of outer cone is a parabola given by $z = \pm y^2/2R$ where $R = 2864.2$
3. All dimensions in millimeters

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Fig. 3

- Axial glass thickness = 130 mm
- Intensification less than 5% on vacuum window
- Clamshells are moderately sensitive to tilt (0.2 mrad FOV)

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Fig. 4

Table 8: Novette f/2 Target Focusing Lenses

Nova Drawing Number: AAA 78-116426, Tab Number 06B

Focal Spot Diameter: 100 μ m (at 1.05 μ m)

50 μ m (at 0.53 μ m)

Distance Between 1.05 μ m and 0.53 μ m Focal Point: 39 mm

Back to Front Surface Beam Intensification: 11%

Center Thickness: 128 mm

NOVETTE BASELINE PHOSPHATE CHAIN

Wavelength 1.053 μm

Fill factor 0.7

Comp numb	Component description	Diam (cm)	Thick (cm)	No. and ang	Refr index	Nonin index	SS gain
1	Apodizer	2.7	0	1	1	0	1
2	SF input	2.7	.5	1	1.507	1.24	0.99
3	Pinhole						1
4	SF output	3.75	0.5	1	1.507	1.24	0.99
5	Wave plate	3.75	0	1	1	0	0.7
6	Rod 50 mm	3.75	40	1	1.523	1.05	20
7	Pockels' isol	3.75	9.5	1	1.5	1	0.87
8	SF input	3.75	0.5	1	1.507	1.24	0.99
9	Pinhole						1
10	SF output	9.17	0.8	1	1.507	1.24	0.99
11	Disk 94 mm	9.17	2.4	6	1.523	1.05	6.5
12	Faraday isol	9.17	4.5	1	1.67	2.1	0.88
13	Disk 94 mm	9.17	2.4	6	1.523	1.05	6.5
14	SF input	9.17	0.8	1	1.507	1.24	0.9199
15	Pinhole						1
16	SF output	15	1.2	1	1.507	1.24	0.99
17	Faraday isol	15	2.5	1	1.67	2.1	0.92
18	Disk 150 mm	15	3	4	1.523	1.05	3.6
19	SF input	15	1.2	1	1.507	1.24	0.9199
20	Pinhole						1

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Table 9

NOVETTE BASELINE PHOSPHATE CHAIN (Cont'd)

<u>Comp numb</u>	<u>Component description</u>	<u>Diam (cm)</u>	<u>Thick (cm)</u>	<u>No. and ang</u>	<u>Refr index</u>	<u>Nonln index</u>	<u>SS gain</u>
21	SF output	20.8	1.7	1	1.507	1.24	0.99
22	Faraday isol	20.8	4	1	1.67	2.1	0.89
23	Disk 208 mm []	20.8	2.5	3	1.523	1.05	2.2
24	Disk 208 mm	20.8	2.5	3	1.523	1.05	2.2
25	Disk 208 mm []	20.8	2.5	3	1.523	1.05	2.2
26	SF input	20.8	1.7	1	1.507	1.24	0.9199
27	Pinhole						1
28	SF output	31.5	2.5	1	1.507	1.24	0.99
29	Faraday isol	31.5	2.5	1	1.67	2.1	0.9
30	Disk 315 mm []	31.5	4.3	2	1.523	1.05	1.7
31	Disk 315 mm []	31.5	4.3	2	1.523	1.05	1.7
32	Disk 315 mm []	31.5	4.3	2	1.523	1.05	1.7
33	Disk 315 mm []	31.5	4.3	2	1.523	1.05	1.7
34	SF input	31.5	2.5	1	1.507	1.24	0.9199
35	Pinhole						1

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NOVETTE BASELINE PHOSPHATE CHAIN (Cont'd)

Comp numb	Component description	Diam (cm)	Thick (cm)	No. and ang	Refr index	NonIn index	SS gain
36	SF output	46	3.7	1	1.507	1.24	0.99
37	Slit apodizer	46	3	1	1.507	1.24	0.99
38	Disk 460 mm [1]	46	4.3	2	1.523	1.05	1.85
39	Disk 460 mm [1]	46	4.3	2	1.523	1.05	1.85
40	Disk 460 mm [1]	46	4.3	2	1.523	1.05	1.85
41	SF input	46	3.7	1	1.507	1.24	0.9199
42	Pinhole						1
43	SF output	74	5.9	1	1.507	1.24	0.99
44	Turning mirror	74	10.3	1	1.507	1.24	1
45	Turning mirror	74	10.3	1	1.507	1.24	0.97
46	Crystal window	74	10	1	1.507	1.24	1
47	KDP crystal	74	1.8	1	1.482	1.0	0.65-0.90
48	Crystal window	74	10	1	1.507	1.24	1
49	Diag splitter	74	8	1	1.507	1.24	0.95
50	1.05 μ beam dump	74	3	1	1.507	1.24	0.95
51	Target chamber window	74	6.5	1	1.507	1.24	0.93
52	Focusing optics						
	f/2 lens	74	12.8	1	1.507	1.24	
	Debris shield	74	1.5	1	1.507	1.24	
	or axicon	74-150	—	1	—	—	

PROJECTED NOVETTE BASELINE CHAIN PERFORMANCE AT 1 ns

02-32-1280-4506

Fig. 5

PROJECTED NOVETTE BASELINE CHAIN PERFORMANCE AT 3 ns

02-32-1280-4502

A ☐

B ☐

Fig. 6

PROJECTED NOVETTE BASELINE CHAIN PERFORMANCE AT 5 ns

Beam diameter	4.2	9.2	14.6	20.8	31.5	46.0	74.0
Energy (KJ)	0.066	0.570	1.122	3.352	7.787	16.202	14.985
Peak entr (J/cm ²)	8.027	18.227	14.030	25.933	25.080	22.391	7.253
Mean Entr (J/cm ²)	0.779	4.406	4.428	12.578	15.842	16.689	5.410
Peak/mean entrance	1.4	1.5	1.5	1.8	1.8	1.6	1.5
Peak exit (J/cm ²)	0.939	1.501	5.827	5.855	7.224	7.915	6.673
Mean exit (J/cm ²)	0.049	0.156	1.386	1.797	3.624	5.200	5.156
Peak/mean exit	1.2	1.3	1.3	1.3	1.3	1.3	1.3
Delta B-integral	1.26	1.04	0.55	1.45	2.81	0.40	0.69
	0.12	0.19	0.15	0.56	1.44	0.22	0.38

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Fig. 7

PROJECTED NOVETTE CHAIN PERFORMANCE

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Baseline - dashed curve & shaded data

Additional Amp - solid curve & unshaded data

Fig. 8

PROJECTED NOVETTE CHAIN PERFORMANCE

02-32-1280-4504

Baseline - dashed curve & shaded data

Additional Amp - solid curve & unshaded data

Fig. 9

PROJECTED NOVETTE CHAIN PERFORMANCE

02-32-1280-4505

Baseline - dashed curve & shaded data

Additional Amp - solid curve & unshaded data

Fig. 10

**1.8 cm KDP TYPE II DOUBLING CRYSTALS WILL PROVIDE
EFFICIENT SECOND HARMONIC ENERGY CONVERSION
FOR THE NOVETTE LASER SYSTEM**

For Novette
 $0.75 \leq I_0 \leq 3.5 \text{ GW/cm}^2$

02-32-1280-4479

Fig. 11

NOVETTE BASELINE CHAIN PERFORMANCE,
1 ω (1.05 μm) AND 2 ω (0.53 μm), "A" AND "B" FLUENCES

02-32-1280-4620

Fig. 12

NOVETTE CHAIN PERFORMANCE WITH ADDITIONAL
46 cm AMPLIFIER, 1ω ($1.05\ \mu\text{m}$) and 2ω ($0.53\ \mu\text{m}$), "B" FLUENCE

02-32-1280-4619

Fig. 13