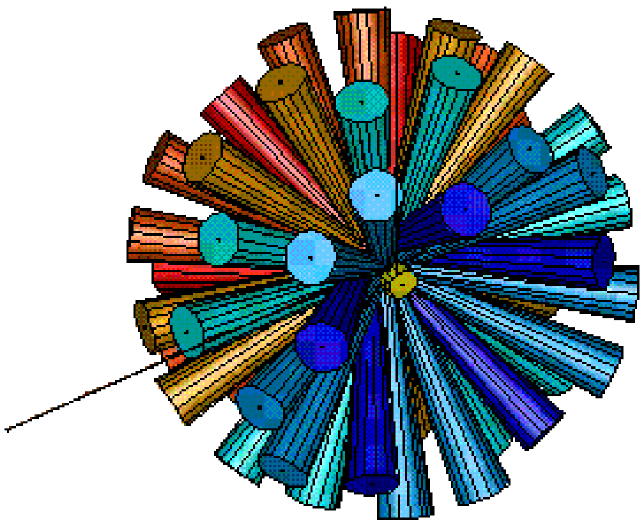
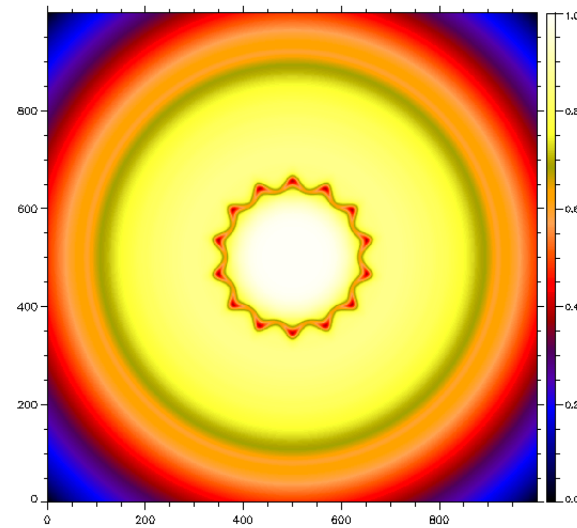
LA-UR-99-6446

Direct Drive Cylindrical Implosions
on the
OMEGA Laser
at the
Laboratory for Laser Energetics
of the
University of Rochester





Post Shot Report
DDCYL Campaign 99-1
May 10-14, 1999

Los Alamos
ICF and Radiation Physics
AWE
HUNTING-BRAE
UNIVERSITY OF FLORIDA
UR LLE

DDCYL 99-1 Post-Shot Report

A Report on the OMEGA Laser Campaign from May 10-14, 1999

Cris W. Barnes, Steve Batha, Pete Walsh, P-24;
David Tubbs, Brad Beck, John Scott, XTA;
Joyce Moore, Harry Bush, Bob Day, Bob Watt, MST-7;
Steve Rothman, Mike Dunne, AWE;
Tom Boehly, LLE

The week of May 10-14, 1999 Los Alamos conducted a campaign of Direct Drive Cylinder Implosions on the OMEGA Laser facility in collaboration with the Laboratory for Laser Energetics of the University of Rochester, the Atomic Weapons Establishment of the United Kingdom, and the University of Florida. This report summarizes the campaign operations and conduct and the status of analysis of results.

Goals

The goals of the 3rd week of Direct Drive Cylinders on OMEGA in 1999 were:

Primary Goals:

A) Understand experimental radiography better (radiograph known static targets)

B) Better understanding of the sources and effects of short wavelength perturbations on the long wavelength RT growth

Secondary Goals:

- *Initiate Richtmyer-Meshkov mix targets*
- *Test beryllium cylinder implosions (if available)*
- *Observe emission spectroscopy from chlorinated foam to study implosions*

To achieve these goals, our game plan was:

- **Tuesday:** Shoot mix targets with late backlighter and confirm set up of radiography; begin static targets
- **Wednesday:** Do sequence of unperturbed and perturbed targets of different smoothness and thickness. Fill in static, beryllium, and chlorinated foam targets.
- **Thursday:** Repeat Wednesday at different backlighter time.

In summary: we got very good results from the static radiographs; we had some combination of target and laser facility issues that resulted in poor dynamic implosion images in contrast to prior campaigns, as well as we learned we had not succeeded in creating and characterizing the appropriate surface roughness of the targets; we did get chlorine emission spectra including a shot with chlorine foam in the implosion; but we did not have a beryllium target to test.

Operations

Comments on Experimental Operations

Personnel this week used a model of a Super-PI (Cris Barnes) with two other persons acting as PI for parts of the experiment to relieve the load on Cris: Steve Rothman (AWE) ran the DDCYLMIX shots, and Steve Batha ran the static radiographs and helped run mornings on the ablative Rayleigh-Taylor shots. Meanwhile, Pete Walsh served as “Lead Tech” and single point-of-contact with OMEGA Experimental Operations about diagnostic setup, alignment, and timing, with all requests for changes by the LANL team funneled through him to XOPs. Tom Sedillo and Tom Ortiz then carefully built and prepared all pinhole-collimators and worked with the LLE techs on the floor to assure quality operations there. These arrangements seemed to work very effectively. Other LANL personnel present included Principal Designer David Tubbs, Brad Beck and John Scott of XTA, and Harry Bush from MST-7 (target fabrication). Some PI responsibilities, like approval of pulse shapes, were effectively handed over to the XTA staff.

Both the PI (Cris Barnes) and the Lead Tech (Pete Walsh) were at OMEGA by Friday, May7 (Cris actually arrived on the evening of the 5^{th}). This lead-time effectively aided pre-shot preparation, especially of the diagnostics, and is strongly recommended for future campaigns.

Only 6 targets were brought by Cris; the remainder were either brought over the weekend by Harry Bush or, for the perturbed targets, actually shipped by Fed Ex arriving Tuesday of shot week. With no Powell Scope (see below) it didn't matter much, but did represent the last-minute rush of finishing the targets that contributed to the quality control.

After two pointing shots and a "rep" of the three types of Mix shots, we scheduled a "Pause" into the schedule (between shots 16471 and 16473). The PI for the shots (Steve Rothman) used this break to confirm that all diagnostics were aligned and timed correctly, and that the laser operations were nominal. Since things seemed to be going well, the actual break took only a few minutes, but it served a very effective purpose and is also highly recommended in future experimental planning. We returned good data on ALL shots from the primary diagnostic, as compared to 20%-30% losses in prior LANL campaigns.

Shot List

Table 1 lists pertinent information about the shots taken during the campaign. It lists the shot number, the target type, the target name, mandrel, and DDCYL9xx.OPD file number of the WYKO surface analysis (available in *.txt format on plasmasys in `/laser_data/mo-box/cbarnes/wyko/AprMay99DDCYL_WYKO/.`); the pulse shape, number of beams, total energy and average energy per beam, and RMS energy balance; and columns for how many degrees the target needed to be rotated during the alignment procedure, whether the alignment fiber was out of the field of view (blank is in view, 1 or 2 is slightly out of the view in one or two directions, and 3 is grossly outside the FOV), and a subjective statement about the quality of the data (see below; zero is good and analyzable, 1 is problematic, and 2 is grossly bad).

Digitized Data

The digitized data is available on plasmasys in `/laser_data/mo-box/cbarnes/lleddcyl/99-1/.` This includes P510, IXRSC, scope traces, and target alignment images in addition to the film images in PDS format.

LLE Step Wedge

During this week all film (Kodak T-Max P3200) had *both* the old LLE continuous wedge and the new LLE step wedge put on the film. Thus a cross-calibration record exists for future use of the step wedge.

Table 1: DDCYL 99-1 Shot List

Shot	Target type	Target name	Mandrel / WYKO#	# of beams on target	Pulse Shape	Total UV on target	UV/ beam	RMS Energy Balance (%)	Degrees target rotated +left - right	Out-of-view align-ment fiber	"Data Quality"
16464	pointing	PT-267		35	SG1011	11679	334	11.5			
16465	pointing	PT-268		35	SG1011	12188	348	10.4			
16467	Low mix	1 Gold 1 Yellow 26	50/32	55	SG1011	22080	401	10.2	3.20		1
16468	high mix	2 Gold 3 Yellow 29A	236/34	55	SG1011	22030	401	9.9	0.10	1	1
16471	high mix gap	3 Gold 2 Yellow 31	81/54	55	SG1011	23043	419	9.7	0.39	1	1
16473	Low mix	1 Gold 3 Yellow 27A	243/40	55	SG1011	23425	426	9.7	2.17		1
16474	high mix	2 Gold 2 Yellow 29	219/39	55	SG1011	23205	422	10.2	1.95	2	1
16475	high mix gap	3 Gold 3 Yellow 31A	234/55	55	SG1011	22350	406	11.1	0.70	2	1
16477	high mix gap	3 Gold 1 Yellow 30	59/53	55	SG1011	22328	406	10.6	0.80		1
16482	standard unpert	1 Red 1 Yellow 1	56/15	55	RM2001	17470	318	16.1	0.00		1
16484	standard m=14	2 Red 2 Yellow 6	99?/64	55	RM2001	18028	328	10.1	1.41	2	0
16485	static 525 no attn	3 Silver 2 Yellow 33	69	5	RM2001	1477	295	10.5	0.80		1
16486	Better m=14	2 Blue 1 Yellow 11	70/76	55	RM2001	18418	335	10	1.20		2
16487	Thicker unpert	1 White 1 Yellow 14	53/22	55	RM2001	18318	333	10.2	0.25	2	1.5
16489	Thicker m=14	2 White 1 Yellow 17	89?/69	55	RM2001	18135	330	10.1	2.97	3	0.5
16490	Better unpert	1 Blue 3 Yellow 10	98/25	55	RM2001	16997	309	13.1	-19.00	1	2
16491	Static 525 attn.	1 Silver 4 Yellow 35	78	5	RM2001	1551	310	8.6	-3.70		0
16493	Static 325 no attn	2 Silver 1 Yellow 37	240	5	RM2001	1554	311	8.9	0.30		1
16496	Better m=14	2 Blue 3 Yellow 13	79/74	55	RM2001	18261	332	10.2	1.20		0
16497	Thicker m=14	2 White 3 Yellow 19	96/70	55	RM2001	18141	330	10.2	0.30		2
16498	Better unpert	1 Blue 1 Yellow 8	71/26	55	RM2001	16025	291	18.1	0.54	2	2
16503	Standard unpert	1 Red 4 Yellow 4	85/17	55	RM2001	17386	316	10.2	1.00		2
16506	Standard m=14	2 Red 3 Yellow 7	235/62	55	RM2001	18687	340	10	12.70	3	1
16508	Better unpert	1 Blue 2 Yellow 9	80/24	55	RM2001	17970	327	15.1	2.24		2
16509	Better m=14	2 Blue 2 Yellow 12	88/72	55	RM2001	17654	321	16.4	1.44	2	1.5
16511	Thicker unpert	1 White 5 Yellow 16B	54/31	55	RM2001	18218	331	10.2	1.36		1.5
16515	Thicker m=14	2 White 2 Yellow 18	91/66	55	RM2001	18426	335	10.5	-1.89		1.5
16518	Cl foam	1 Green 1 Yellow 20	78/30	55	RM2001	18557	337	11.9	-11.70		2
16520	Static 525 no attn	3 Silver 1 Yellow 32	216	5	RM2001	1642	328	7.6	0.90		0
16521	Thicker unpert	1 White 6 Yellow 16C	58/36	55	RM2001	18342	333	15.1	1.94	2	1
16522	Static 525 attn.	1 Silver 3 Yellow 34	85	5	RM2001	1696	339	7.4	1.70		0
16524	Cl foam	1 Green 2 Yellow 21	69/29	55	RM2001	18407	335	10.1	2.71		2

Diagnostic Timings

Using the LLESPLOT/PVWAVE and reduceTiming routines at Rochester we documented the TIM-based x-ray framing camera (XRFC) timings during the shot week. We were happy to obtain and use interstrip timing shots as the first shot stored of each day. The XRFC4 (primary diagnostic) and XRFC3 sheets are complete; for XRFC1, ringing in the comb pulse prevented the reduceTiming –4 routine from finding all the peaks and we never hand-did all the shots, so beware of blanks. The timing sheets are shown in the attachments.

Problems

Observed Issues with Results

The primary issue from the DDCYL 99-1 campaign is that all but about two of the dynamic implosions showed marker layers that were "fluffy", asymmetric, broken up, "diffuse", and generally unacceptable. They exhibit 3-D effects, anomalous mix and shell breakup. This is in *sharp* contrast to images from the two campaigns in 1998.[1] In addition, transverse views of the targets from XRFC3 often showed rotated targets and/or "differential bowing" (one side curved noticeably more than the other). Some early-in-time images did not appear too bad, but by maximum convergence most images (and *all* of the unperturbed shots) showed horrible marker layers.

We believe that results were affected by one or more of the following: target anomalies (observable but passed as OK or present but unseen); misunderstood or uncontrolled surface roughness; and operational difficulties (target alignment, metrology, and laser conditions). Initially it appeared that systematically (with variance) the targets and the lasers were not correctly aligned and the resulting drive was both axially and azimuthally asymmetric. However, as detailed below, no *significant* problems with alignment or laser quality was found. (The rotational metrology and alignment could have had few-to-several degree offsets, which corresponds to tilted images in the XRFC3 view from TIM3, but this is not considered a root cause of the most important problems though it will need to be fixed in the future.)

Consider shot 16503, which from Table 1 had only a small rotation correction, had its alignment fiducial in the field of view, and had as good energy balance as was achieved during the week. But Figure 1 shows the incredibly lousy images achieved of this unperturbed target.

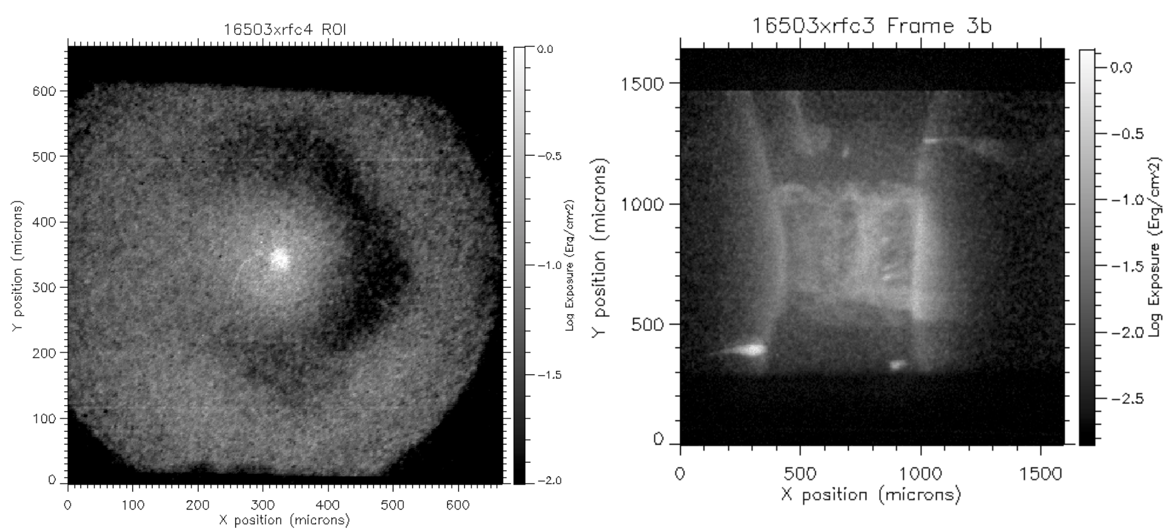


Figure 1:a) XRFC4 image Frame 3b for shot 16503.b) XRFC3 image Frame 3b for same shot. See the "differential bowing" on this shot.

[1] See the Web image archive for previous campaigns at `http://plasmasys.lanl.gov/OMEGA/`

We think these cylindrical implosions can provide a very good validation of LASNEX. We believe the issue of mode coupling of short wavelengths affecting long wavelengths is an interesting problem, especially if driven by surface finish (fabrication) rather than direct drive laser speckle. We thus believe we did a good design review in January, 1999, and the program we laid out at that time (of characterizing, improving, and controlling the target surface finish for a smooth/rough and thin/thick ablator comparison) was the correct direction to go.

We did not get those targets. What is needed is further development:

- Documentation of just what we are measuring with the WYKO, until we can believe we know a target's surface finish is some value that is azimuthally symmetric;

- Further demonstration that we can then produce "several" targets with reproducible, controllable, surface finish.

Finally, more time is needed after precision machining to allow for better "quality control" and double-checking of metrology of assembled targets.

We would then be in a position to request a "complete" set of targets that meet design requirements to study short wavelength surface roughness effects. Coupled with improved control of laser and facility conditions (with special attention paid to energy balance and alignment issues) we would expect to return to the excellent results of 1998.

Target Fabrication Issues

Polymers and Machining

Making a full extended-shift week's worth of cylindrical targets taxed the target fabrication team considerably, at a time of personnel change[2] that did not help the situation. Forty-one targets were delivered, and an additional 8 lost, broken, or not made. There were tremendous issues with "dipping" the styrenes and successfully annealing them in the oven. Thick dichlorostyrene layers (for the static targets) could not be successfully made, and we used monochlorostyrene instead. There are continuing questions under R&D study about the polymers used and any contaminants like water. There was also a problem with some of the targets buldging at the waist. We've seen this before and it seems to happen only on cylinders with tracer bands. There were two cylinder that split around the diameter while the foam was being inserted. This has to do with extensive cracking on the cylinders, with some cylinders showing more than others. This was also partially due to the foam being unevenly machined, with one end being bigger in diameter than the other and it taking a lot of force to push the foam inside the cylinders.

Many small static cylinders were lost during the manufacturing and assembly process. They are very fragile when on the mandrel and easily bent. When they are leached they are very small, staticy, and almost impossible to find if they jump out of a dish (which they like to do). Since they are so hard to make, perhaps something could be done (possibly some color added) to make them easier to find if lost.

[2] David Sandoval took over the precision machining from Gerry Rivera; Warren Steckle took over some of Joe Duke's responsibilities with the polymers; Bob Watt took over team leadership of target fab from Pete Gobby; and Harry Bush was about to retire.

The machining went pretty well. In particular Doug Hatch did very well cutting the "gears" on the static targets. However, a "couple" of targets ended up with a sawtooth pattern on the edge of the marker band; see 2 Red 3 Yellow 7 shot 16506 for an example.

During development we believe we learned that leaching the aluminum mandrels in different dilutions of NaOH (and hence at different speeds) did affect the surface roughness. This was used to differentiate between the "standard" and "better" finishes requested.

There was a problem with the first 3 Al flash PCD runs. The Al was flaky and easily removed by a brush. The very last run (on the perturbed targets) was excellent (like previous campaigns) very shiny with no blotches and not easily removed

Surface Finish Characterization

A major goal of the target fabrication was to end up with a set of targets with the surface roughness measured and then sorted into "standard" and "better" finish. We underestimated the difficulty of learning how to use the WYKO interferometer to measure the surface roughness appropriately on curved machined surfaces; this is an ongoing, continuing R&D project. In particular, we completed analysis just *after* the week of experiments of a set of 5 measurements on a single target, to discover either a) the target is not azimuthally smooth and/or b) our measurements have some bias in them (see Figure 2).

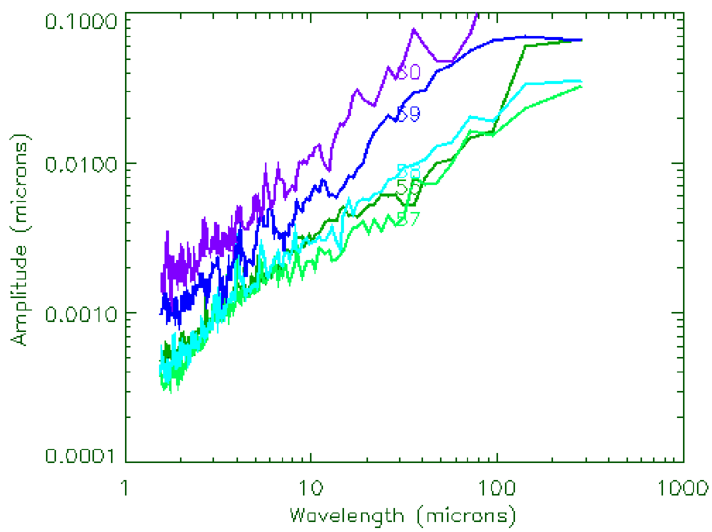


Figure 2: Surface Roughness as measured by WYKO on mandrel 234 at five different angular locations.

Quality Control

There were two targets that upon inspection were grossly problematic. More time was needed in inspection of the targets. Not having the Powell Scope at LLE and thus not reviewing the targets as they arrived contributed significantly to the problem.

Alignment Issues

We had 10 targets remaining, one of which (1 Silver 5 Yellow) was melted and not useable (see Critique Sheet). Two targets (the "noodle", 1 Red 5 Yellow, and 1 Green 4 Yellow which appeared trapezoidal in cross section [conical?]) were difficult to define the rotation angle, and were off from the metrology values by 1.6-2.0 degrees.

One target (1 White 3 Yellow) was measured twice by Cris and twice(originally and later) by Harry; we disagreed by over one degree. Cris measured 1 Green 3 Yellow and got a different answer by one degree the second time, now agreeing with Harry's measurements before and after (so my mistake). The other five targets (including 1 Gold 2 Yellow remeasured by Steve in England) are consistent with a 0.4 degree one-sigma measurement accuracy and preciseness: that is, the measurements and re-measurements all seem to be within 0.8 degrees (or two-sigma) of each other.

Cris also double-checked the alignment fiber measurements on about 5 of the 9 useable targets. The "X Y Z" values are within about 20 microns (one-sigma) of the original measurements in all cases. We have documented pictures of as-shot target alignment and can confirm the targets were aligned as requested to the fiducial. We have also checked the spreadsheet that generates the fiducial location for the TVS views and confirmed no errors there. For some shots (see Table 1) the alignment fiber was just (or in cases listed as “3” considerably) off the edge of the field-of-view (FOV), but this is not correlated with quality of the shot; that is, some bad shots were in the FOV and are confirmed to be correctly aligned.

A 0.8 degree mis-rotation would move the alignment fiber at the "other end" of the cylinder by 0.8 * \pi/180 * 2000 microns = 28 microns, and the center of the cylinder by half this. We can confirm the positioning of the alignment fiber in the TVS viewing system within 3 pixels or 30 microns of where they are supposed to be. Thus I estimate the total misalignment uncertainty to be no more than about 3 of these 30-micron errors independently added up, or about 50 microns(one-sigma). We do not think this is enough to cause the observed problems. Another example in Table 1 like Figure 1: shot 16497 had minimal rotation needed, had an alignment fiber in the FOV, had as good energy balance as achieved that week, and had grossly bad data.

Laser Facility Issues

A key problem with this campaign was that the energy performance of the laser was not good. We only averaged 412 J/beam UV in SG1011 (1 ns square) instead of 450; we got 327 J/beam UV in RM2001 (2.5 ns linear ramp) instead of 345 a year ago (16.5 kJ instead of 19 kJ); this resulted in an average of 12% RMS energy balance (best was 10%, up to 16%-18% for some shots) with correspondingly bad power balance. While the documented pointing and timing of the beams appeared good (from the pointing shots and XRFC gated images of the spots on the pointing targets), the energy was bad. But during the week Sam Morse, LLE head of operations, claimed to have the front-end turned all the way up and did not understand the source of the reduced output energy. There seemed to be no appreciable issue with any prepulse on the monitored beam. With no obvious choice of what to do to fix things, we continued to shoot. A few weeks subsequent it was learned that “free lasing in the edges of the rods of the ring laser [the LARA] which energy was picked up by the monitors but not passed into the amplifier chain through the apertures; hence the system was being underdriven.”[3] It is the opinion of experts that this problem in no way should have contributed to poor beam quality on target. It is

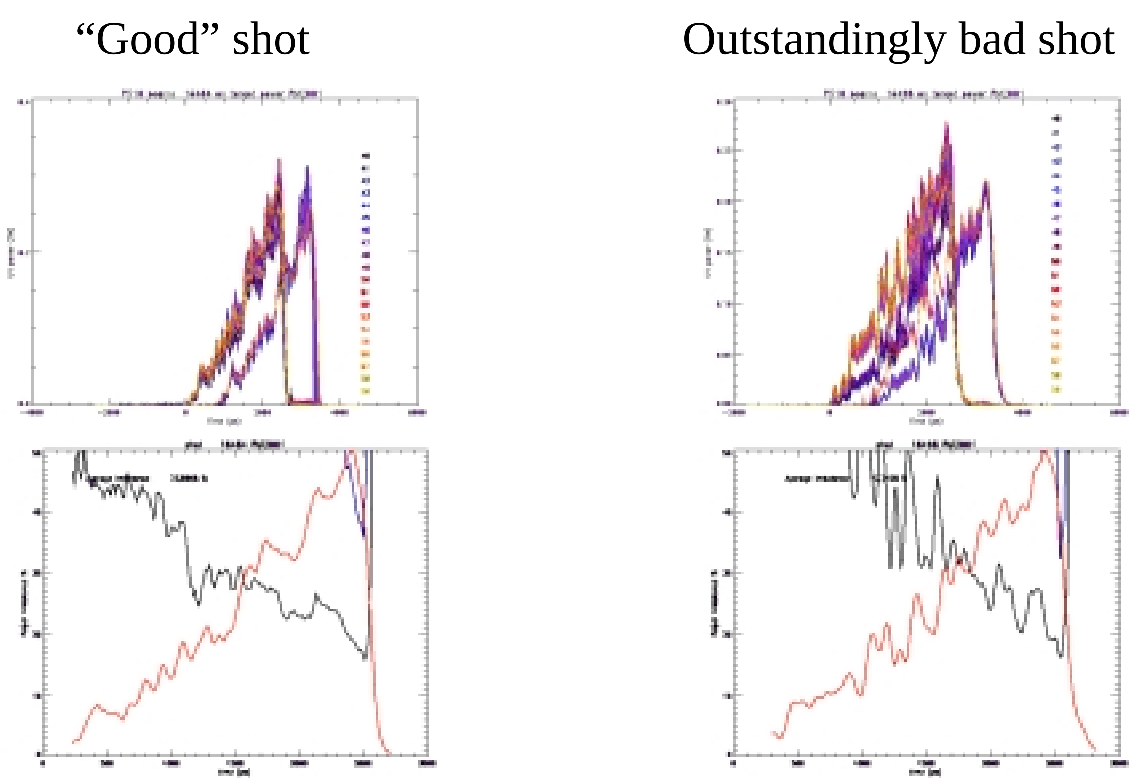
[3] From phone conversation with Sam Morse, documented in e-mail message of 14-Jul-1999.

recommended that PIs monitor the minimum IR beam energy and stop shooting targets if that energy drops below about 600 J.

Another issue was the Powell Scope being out for repairs (it was due back 3-4 weeks before the shots, but the repairs slipped). This prevented review of the targets at LLE and affected quality control. Another recommendation is that the Powell Scope be mandatory for our operations. Subsequently it has been repaired and the software effectively upgraded to handle the new target position in Hex2.

For the first time we used “official” alignment procedures (as opposed to previous unofficial but tested procedures). As a result (see Critique Sheet) it was possible for the XOPS operator to do the rotation alignment without the PI being present. PIs remember differently, but at least one (Cris) admits to usually getting to XOPS after the rotation alignment had been done, and Greg Pien (head of OMEGA XOPs) admitted in retrospect that the backlash may not have been correctly handled. After the shot there is no record (unlike the target alignment photos that show the x-y alignment fiducial as shot) to confirm the rotation alignment. The low resolution LLE target sensor system showed different targets being in slightly different positions after alignment; this was troubling at the time but again without Powell Scope nothing could be checked. In retrospect, it is thus possible that backlash was NOT taken out of the rotation, and routine 2.5^{o} misalignments were caused, despite the documented accuracy of the rotation calibration of the TPS-1.[4]

Figure 3: Examples of “Good”(shot 16484) and outstandingly bad (shot 16498) Power Balance. We don’t have software tools yet to easily assess this for all shots, but we think this effect was not usual during this week.



[4] See memorandum by G. Pien dated 2 July, 1998, “Target Positioning System (TPS) Omega-Axis Calibration Test.”

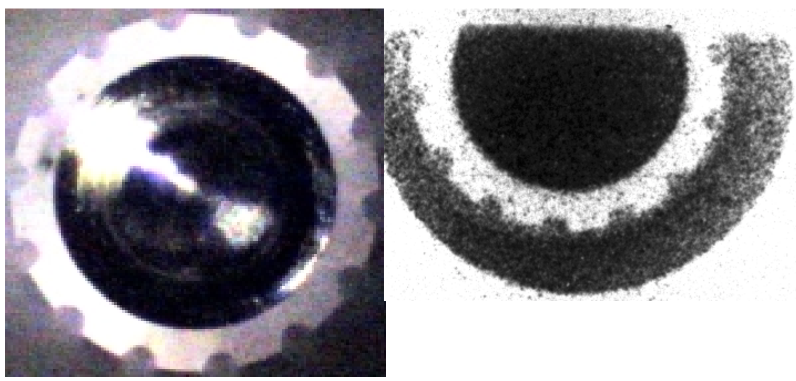
Experimental Results

Static Radiographs

One of the successes of this campaign was the images of the static targets. Difficulties with the extremely small size of the smaller targets resulted in only one successful target being made, but 4 large ones were made. Figure 4 shows an example of the pre-shot optical photo that helped metrologize the targets, and the x-ray radiograph. These results are under active analysis led by John Scott and Brad Beck of XTA and Steve Batha of P-24.

Figure 4: Initial optical photo and x-ray radiograph of large static target

After machining **Framing camera image**



Richtmyer-Meshkov Mix Shots (AWE)

"Low-Mix" targets (chlorinated marker layer; see shot 16473) show ugly, asymmetric, broad marker layers. "High-Mix" targets are big, but how much is due to mix? We do see effect of inner gap defect (the "slug" seen at about 3:30 in Figure 5a); making this defect was a target fab tour de force. Are streamers on outside a result of interaction with ablation front, despite 60-micron plastic overcoat? We will repeat these shots in DDCYL 00-1 in January, 2000.

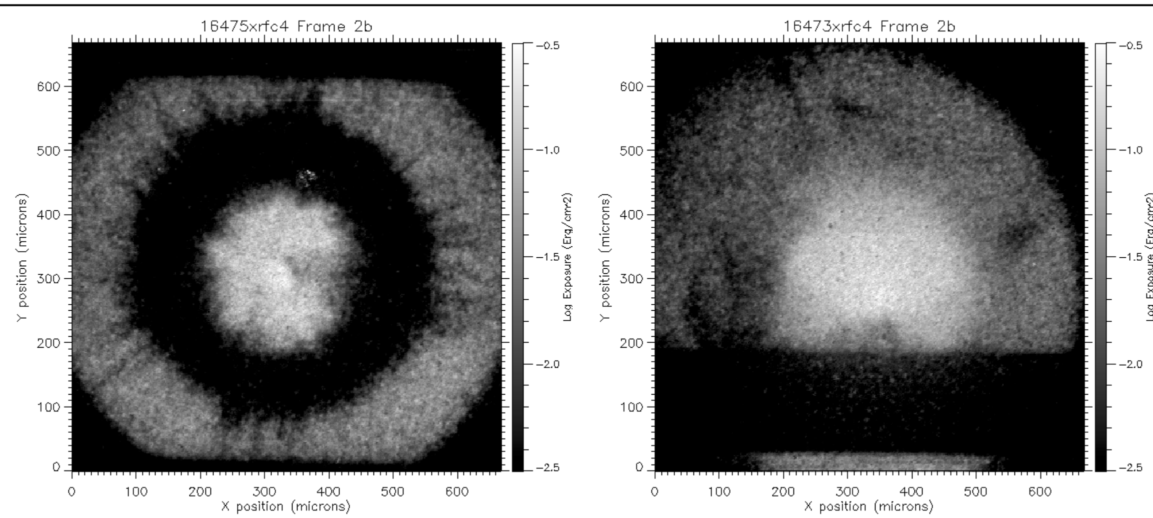
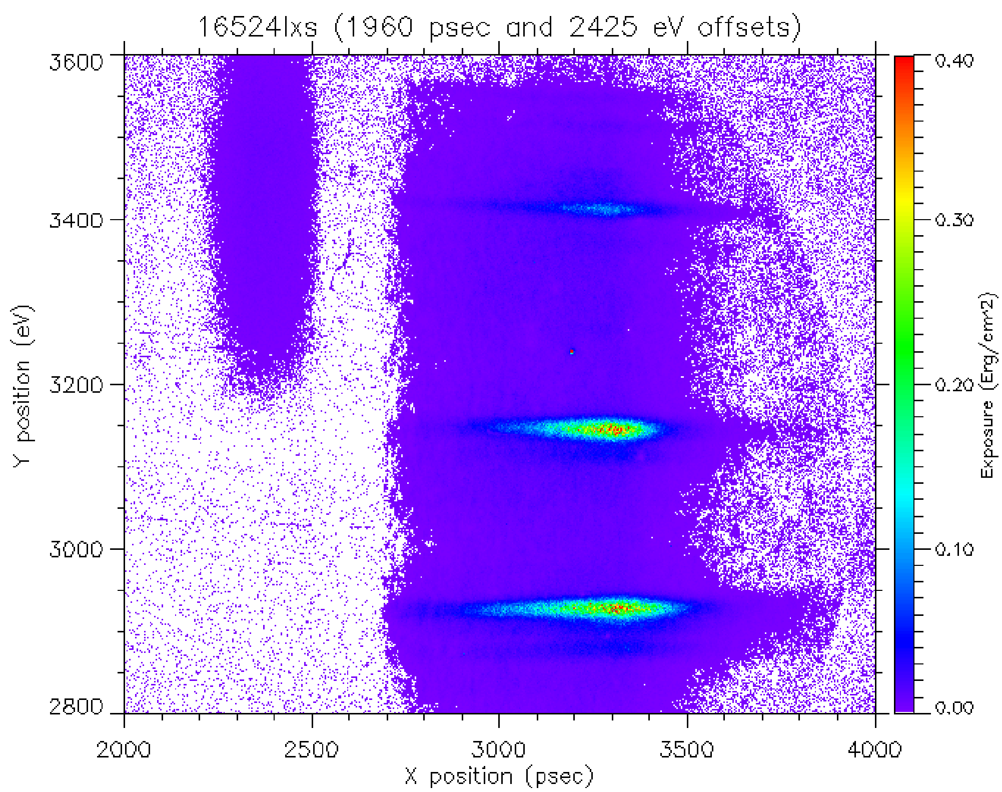


Figure 5: XRFC4 radiographs of high mix with defect shot 16475 and supposed low-mix shot 16473.

Chlorine Emission Spectra (U of Florida)

Thanks to significant help from Paul Jaanamagi of LLE, the LXS returned streaked spectra from both chlorinated marker and chlorinated foam implosions. Without the UV fiducial on the image we do have some questions about the timing of the diagnostic; in general, it was a useful exercise in developing this technique and did provide one very interesting spectra from a chlorinated implosion (see shot 16524) which is being analyzed by Don Haynes (formerly of U. of Florida, now U. of Wisconsin).[5]

Figure 6: LXS Spectra from shot 16524. 1.6 psec/pixel and 0.73 eV/pixel have been used; the zero offsets are arbitrary (the energy one from analysis of 13315) and may certainly be wrong but should be illustrative.



[5] See Web pages at `http://www.lanl.gov/orgs/p/p-24/OMEGA` for details of this and other analysis of OMEGA diagnostics.

Future Directions for Ablative Rayleigh Taylor Work

The target fabrication issues of production, measurement, and characterization of surface roughness are of wide importance to the ICF&Radiation Physics Program. To move forward on the Ablative Rayleigh-Taylor campaign we must put in place process improvements. We envision and propose 3 deliverables to come from the R&D efforts on improved fabrication of these cylindrical targets for future campaigns:

(1) Accurate and reproducible measurements of surface roughness and surface characteristics (e.g., imposed perturbations) for cylindrical targets with diameter approximately 900 microns or larger;

(2) Accurate and reproducible fabrication of the materials used in DDCYL targets (e.g., polystyrene and doped polystyrene); and

(3) Accurate and reproducible surface finish and surface characteristics fabricated on ablators used by the DDCYL campaign.

We've been somewhat non-specific on the target materials in these deliverables. We think it's appropriate to begin with materials we now use (polystyrene solid and foams and doped polystyrene), but we'd like to allow for the need to consider alternative or better materials in future designs. We also have tried not to over-specify details and timelines or presume personnel assignments in the milestones. Such decisions are part of the expectations and considerations for project needs.

We see the following milestones for each of the 3 deliverables:

(1) Measurement of surfaces

(a) determine metrics for accuracy and reproducibility (requires input from entire DDCYL team);

(b) assess present surface-finish data and measurement techniques;

(c) identify (and procure, if necessary) the appropriate measurement instrument, techniques, and MST-7 resources;

(d) measure the surface finish, according to metrics, for DDCYL targets available from the Jan/Jul 98 and May 99 campaigns;

(e) document techniques and results; and

(f) measure the surface finish and imposed surface characteristics, according to metrics, and distribute the data to the DDCYL team in sufficient time to meet campaign needs on future shots.

(2) Material properties

(a) identify relevant material properties (e.g., density, structural integrity, etc.) and determine metrics for fabrication accuracy and reproducibility (requires input from entire DDCYL team);

(b) identify the fabrication process(es) and (procuring, if necessary) MST-7 resources that meet the metrics;

(c) demonstrate the process in fabrication of targets identified below in milestone 3(d); and

(d) measure material properties according to metrics and document data to DDCYL team on all targets fabricated for future DDCYL experiments.

(3) Fabrication of surface finish

(a) determine metrics for accuracy and reproducibility (requires input from entire DDCYL team);

(b) assess current fabrication process(es);

(c) identify (and procure, if necessary) MST-7 resources and develop process to fabricate target surface finish according to metrics;

(d) demonstrate process in fabrication of the following target suite (to be used in future DDCYL experiments):

4 targets with unperturbed surfaces fabricated "identically" to those shot in Jan 98

8 targets (4 unperturbed, 4 perturbed with m=14 1-micron sinusoids) fabricated by new process to control surface roughness and desired surface characteristics; and

(e) document fabrication process and techniques.

Attachments

(Critique Sheet)

Critique sheet

(fill in the highlighted regions)
Week of: May 11-14, 1999
PI: Cris Barnes
Experimental series: DDCYL 99-1
Date of submitted: June 3, 1999

Main diagnostics: XRFC4, LXS, XRFC3, SSC1, XRFC1, IXRSC, pinhole cameras, P510 a&b streak cameras (I requested SBS backscatter on BL26 [sic, should have been BL25] but apparently failed to get it.)

Main objectives: Primary: *A) Understand experimental radiography better (radiograph known static targets) B) Better understanding of the sources and effects of short wavelength perturbations on the long wavelength RT growth.* Secondary: *Initiate Richtmyer-Meshkov mix targets. Observe emission spectroscopy from chlorinated foam to study implosions*

Problems encountered:
(I try to remain as "factual" as possible in these comments. Where I feel appropriate, I provide comments or suggestions in this blue font.)

Laser:
The laser energy was low, with the average IR energy/beam only 710 J instead of 750 J and hence UV on-target total energy only 16.4 kJ. Also, the beam energy balance was worse than before, generally 10% at best to as bad as 18%. (In January '98 we got 19 kJ and in July '98 we got 18.5 kJ, both times with 6.2%-9% beam energy balance.) I was told the "front end" was turned all the way up yet the IR output was not near red line; this was not understood at the time.
I required significant pre-shot-week effort to get operational LLE software to look at the P510 data (a thank you to Bill Donaldson for all his help), and it still does not deal correctly with delayed backlighter beams. That data show on some shots (see 16498 for example) excessive beam power imbalance.
Pulse shapes were very reproducible and acceptable, very close to the requested linear ramps.
Beam 33 had a new Frequency Conversion Crystal and was supposed to be ramped up over the first three shots. I tried to coordinate this with lasers and shot director and thought I had; it still fired first time at 557 J UV.
RMS pointing accuracy was 43 microns, acceptable but greater than previously achieved. The printed report with pictures was very nice and excellent documentation. Beam timing seemed nominal from pointing shot data in framing cameras.

Experimental diagnostics:

The expected t0 times for the TIM-based diagnostics were available for all our requested systems and very close to correct, apparently within a few hundred picoseconds. This was great.

The zero-interstrip timing shots first thing each day immediately identified an unexpected Kentech pulser trombone delay between strips 2 and 3 on XRFC4. This is an excellent operational advance. However, we at Los Alamos are still not authorized to view data from these "shots" in the query database, despite specific requests.

We had only the tiniest problems with XRFC alignment or magnification. The new snout assembly with stainless steel collar appears to be a significant improvement. There is a small rotation of the snout assembly and pinhole array. Its shot-to-shot alignment jitter appears to be about 150 microns.

The trigger for XRFC3 had problems (power supply) and it failed to return data on 8 out of 32 shots.

We had problems with our Los Alamos-purchased pinholes and collimators from Resonetics matching up. In particular many frames on XRFC1 were lost apparently to pinhole-collimator mismatch. Also, the film contact on XRFC1 may not be quite right as the center columns of images appear out-of-focus (some crud in the camera?) Thank you to OMEGA operations for loaning us good pinholes.

Apparent miscommunication between Paul Jaanamagi and XOps on timing of the LXS and whether its monitor trace should be believed resulted in some anomalous timing changes.

The IXRSC took a while to get going and then failed to return data on a few shots. (It wasn't getting correctly armed by XOps and the gate valve didn't open?)

We successfully got both the old continuous P11 wedge and the new step wedge on all of our film, allowing us to document the transfer to the new wedge standard. All film was correctly processed by darkroom staff.

Experimental problems:

Watch rollover and changes between shot configurations all seemed to go very smoothly.

Making up the multiple copies of the SRFs and viewgraphs at night for the 8am watch briefing next morning is made more difficult by a) the printer in the "War Room" not working (certainly not from the Mac in there) and b) the only printer with built-in transparency capability being colorlw down in the imaging area with no supplies late at night.

Target problems:

The Powell Scope, sent in for repairs in late March and expected back by late April, still has not returned from repairs at Newport. Knowing this, we made the choice to go forward with the experiment relying on single-point-of-failure metrology done at Los Alamos and only inspection for transit damage at Rochester. Some problems with the quality of our physics may stem from metrology problems; we have been doing post-mortems on the remaining targets back at Los Alamos.

I brought six targets with me on the Wednesday before the shots; about 25 shots worth came on Sunday, and the last 7 shots worth had to be FedEx'd arriving on Tuesday. This "lateness" exacerbated the pressures on target metrology and documentation. This is not an OMEGA facility problem, other than the perceived pressure that we cannot cancel shots within about two months of scheduled date, which was still a time when we appeared way ahead on target production. Los Alamos will be trying to learn to deal with the pressures that extended shift operation are placing on target fab.

It is a fact that until the moment Tuesday morning that our first target began to be aligned by XOps that I did not understand that the alignment process had been formally proceduralized.

In retrospect I now remember words said and written to me, etc., but I did not place them in context and understand. In particular, while I was given an alignment procedure by Greg Pien on Monday, I did not have to formally approve it (by signature). I did not expect to use it but rather my procedure developed over the previous two run weeks last year. Thus one known sign error and a graphics error had to be corrected on the fly.

As part of this I did not know until arrival at Rochester that the ability to generate on-screen reticules from R,theta,phi coordinates had been disabled. Thus requests from Greg in the weeks prior to the experiment for target alignment information had not been given high priority by me because I was thinking we already knew how to do this and would follow the old procedures. [National Laboratory PIs should be put onto omega_experiments mailing lists and kept up-to-date with operational changes to the facility when they happen.]

To create the new alignment procedure Greg requested one target of each type for tests on Monday. The static target was “melted” in an accident when an alignment laser was used during target insertion. I choose not to risk another target (not understanding the proceduralization….see above). Subsequent alignment problems with the static targets because of mistaken manufacture (see below) thus had to be dealt with in real time during the run week.

Alignment fiber tip was put on top and returned to its original length; I thought this would keep it in view. However, it sometimes now went off the bottom of the narrow view and we had corresponding alignment problems. The new “ultra-wide” view appears useless for detailed (sub-100 micron accuracy) alignment.

The static targets were made with the backlighter the same distance from the *end* of the cylinder as the normal targets, rather than the same distance from the center of the cylinder. This was not caught before the targets were attempted to be used. Having the backlighter closer on a couple targets obscured the alignment fiber in the ny view making alignment very difficult.

One target was broken upon insertion; we had a spare. One foil target, not used, was broken during inspection.

Suggestions for improvements:

If LANL wants to repair or really fix any of our targets on site, an assembly station is required. We are considering options such as moving the LANL assembly station from Nova.

With the closure of Dunkin’ Donuts, we need recommendations on where to go for chocolate donuts.

Positive feedback:

XRFC4 is a great camera giving wonderful images. We got all primary diagnostic data from this camera on all shots.

We did get emission spectrum from chlorinated foam implosion; many thanks to all the work done by Paul Jaanamagi in support of this.

The diagnostic monitor system seemed to work quite well for timing the cameras.

The LLE staff have been very helpful and supportive of our experiments, and we gratefully appreciate it!

Diagnostic Timing Sheets

XRFC4

timing for shots in the ddcyl series #3 (99-1) 5/11-13/99
3c on 16464 and 1c.5 on 16465

shot	f1f2	f2f3	f3f4	tc12	tc23	tc34	tf1abs0	tf1	f1abs	f2abs	f3abs	f4abs	Mag
16459	2.52	2.76	2.4	2.53	2.73	2.41	25.79	25.68	-0.11	-0.12	-0.09	**-0.10**	
16464	2.74	3.02	2.68	2.53	2.73	2.41	25.79	25.12	-0.67	-0.46	-0.17	**0.10**	2X
16465	2.80	3.00	2.66	2.53	2.73	2.41	25.79	25.70	-0.09	0.18	0.45	**0.70**	2X
16467	2.76	3.00	2.66	2.53	2.73	2.41	26.147	29.90	3.75	3.98	4.25	**4.50**	12X
16468	2.76	3.00	2.68	2.53	2.73	2.41	26.147	30.10	3.95	4.18	4.45	**4.72**	12X
16471	2.78	3.00	2.66	2.53	2.73	2.41	26.147	30.16	4.01	4.26	4.53	**4.78**	12X
16473	2.74	3.02	2.68	2.53	2.73	2.41	26.147	30.24	4.09	4.30	4.59	**4.86**	12X
16474	2.76	2.96	2.68	2.53	2.73	2.41	26.147	30.38	4.23	4.46	4.69	**4.96**	12X
16475	2.80	3.00	2.68	2.53	2.73	2.41	26.147	30.32	4.17	4.44	4.71	**4.98**	12X
16477	2.76	2.96	2.72	2.53	2.73	2.41	26.147	30.26	4.11	4.34	4.57	**4.88**	12X
16480	2.54	2.72	2.42	2.53	2.73	2.41	26.147	30.38	4.23	4.24	4.23	**4.24**	12X
16482	2.94	3.08	2.88	2.53	2.73	2.41	26.147	28.20	2.05	2.46	2.81	**3.28**	12X
16484	2.96	3.08	2.86	2.53	2.73	2.41	26.147	27.96	1.81	2.24	2.59	**3.04**	12X
16485	2.92	3.10	2.9	2.53	2.73	2.41	26.147	28.02	1.87	2.26	2.63	**3.12**	12X
16486	2.96	3.06	2.9	2.53	2.73	2.41	26.147	28.14	1.99	2.42	2.75	**3.24**	12X
16487	2.96	3.08	2.88	2.53	2.73	2.41	26.147	28.18	2.03	2.46	2.81	**3.28**	12X
16489	2.96	3.10	2.86	2.53	2.73	2.41	26.147	28.20	2.05	2.48	2.85	**3.30**	12X
16490	2.94	3.12	2.86	2.53	2.73	2.41	26.147	28.12	1.97	2.38	2.77	**3.22**	12X
16491	2.90	3.12	2.88	2.53	2.73	2.41	26.147	28.28	2.13	2.50	2.89	**3.36**	12X
16493	2.96	3.06	2.9	2.53	2.73	2.41	26.147	28.20	2.05	2.48	2.81	**3.30**	12X
16496	2.94	3.12	2.86	2.53	2.73	2.41	26.147	28.26	2.11	2.52	2.91	**3.36**	12X
16497	2.96	3.08	2.88	2.53	2.73	2.41	26.147	28.20	2.05	2.48	2.83	**3.30**	12X
16498	2.96	3.06	2.88	2.53	2.73	2.41	26.147	28.36	2.21	2.64	2.97	**3.44**	12X
16500	2.54	2.72	2.42	2.53	2.73	2.41	26.147	28.18	2.03	2.04	2.03	**2.04**	12X
16503	2.96	3.08	2.86	2.53	2.73	2.41	26.147	28.54	2.39	2.82	3.17	**3.62**	12X
16506	2.94	3.10	2.86	2.53	2.73	2.41	26.147	28.54	2.39	2.80	3.17	**3.62**	12X
16508	2.96	3.10	2.9	2.53	2.73	2.41	26.147	28.56	2.41	2.84	3.21	**3.70**	12X
16509	2.94	3.08	2.9	2.53	2.73	2.41	26.147	28.50	2.35	2.76	3.11	**3.60**	12X
16511	2.94	3.12	2.88	2.53	2.73	2.41	26.147	28.54	2.39	2.80	3.19	**3.66**	12X
16515	2.96	3.06	2.9	2.53	2.73	2.41	26.147	28.58	2.43	2.86	3.19	**3.68**	12X
16518	2.90	3.10	2.92	2.53	2.73	2.41	26.147	28.66	2.51	2.88	3.25	**3.76**	12X
16520	2.94	3.06	2.9	2.53	2.73	2.41	26.147	28.58	2.43	2.84	3.17	**3.66**	12X
16521	2.96	3.06	2.9	2.53	2.73	2.41	26.147	28.68	2.53	2.96	3.29	**3.78**	12X
16522	2.96	3.08	2.88	2.53	2.73	2.41	26.147	28.54	2.39	2.82	3.17	**3.64**	12X
16524	2.96	3.06	2.9	2.53	2.73	2.41	26.147	28.68	2.53	2.96	3.29	**3.78**	12X

XRFC3

timing for shots in the ddcyl series #3 (99-1) 5/11-13/99
3a on 16464 and 2b on 16465

shot	f1f2	f2f3	f3f4	tc12	tc23	tc34	tf1abs0	tf1	f1abs	f2abs	f3abs	f4abs	Mag
16459	2.58	2.50	2.58	2.58	2.54	2.57	26.22	27.32	1.10	1.10	1.06	**1.07**	
16464	2.80	2.84	2.68	2.58	2.54	2.57	26.22	25.56	-0.66	-0.44	-0.14	**-0.03**	2X
16465	2.80	2.82	2.7	2.58	2.54	2.57	26.22	26.02	-0.20	0.02	0.30	**0.43**	2X
16467	3.16	6.28	3.12	2.58	2.54	2.57	26.24	26.20	-0.04	0.54	4.28	**4.83**	6X
16468				2.58	2.54	2.57	26.24						6X
16471	3.20	6.29	3.09	2.58	2.54	2.57	26.24	26.18	-0.06	0.56	4.31	**4.83**	6X
16473	3.22	6.25	3.12	2.58	2.54	2.57	26.24	26.10	-0.14	0.50	4.21	**4.76**	6X
16474	3.19	6.20	3.12	2.58	2.54	2.57	26.24	26.18	-0.06	0.55	4.21	**4.76**	6X
16475	3.19	6.24	3.12	2.58	2.54	2.57	26.24	26.24	0.00	0.61	4.31	**4.86**	6X
16477	3.19	6.22	3.16	2.58	2.54	2.57	26.24	26.20	-0.04	0.57	4.25	**4.84**	6X
16480	2.58	2.58	2.56	2.58	2.54	2.57	26.24	26.30	0.06	0.06	0.10	**0.09**	6X
16482				2.58	2.54	2.57	26.24						6X
16484	3.02	2.90	2.88	2.58	2.54	2.57	26.24	27.80	1.56	2.00	2.36	**2.67**	6X
16485	2.98	2.96	2.88	2.58	2.54	2.57	26.24	27.90	1.66	2.06	2.48	**2.79**	6X
16486	2.98	2.96	2.88	2.58	2.54	2.57	26.24	27.90	1.66	2.06	2.48	**2.79**	6X
16487	2.98	2.94	2.9	2.58	2.54	2.57	26.24	28.06	1.82	2.22	2.62	**2.95**	6X
16489	2.98	2.94	2.86	2.58	2.54	2.57	26.24	28.02	1.78	2.18	2.58	**2.87**	6X
16490				2.58	2.54	2.57	26.24						6X
16491				2.58	2.54	2.57	26.24						6X
16493	2.98	2.96	2.88	2.58	2.54	2.57	26.24	28.06	1.82	2.22	2.64	**2.95**	6X
16496	2.98	2.92	2.9	2.58	2.54	2.57	26.24	28.02	1.78	2.18	2.56	**2.89**	6X
16497	3.00	2.94	2.86	2.58	2.54	2.57	26.24	28.12	1.88	2.30	2.70	**2.99**	6X
16498				2.58	2.54	2.57	26.24						6X
16500	2.60	2.54	2.58	2.58	2.54	2.57	26.24	28.12	1.88	1.90	1.90	**1.91**	6X
16503	2.96	2.94	2.88	2.58	2.54	2.57	26.24	27.42	1.18	1.56	1.96	**2.27**	6X
16506				2.58	2.54	2.57	26.24						6X
16508	2.98	2.94	2.88	2.58	2.54	2.57	26.24	29.26	3.02	3.42	3.82	**4.13**	6X
16509	2.98	2.94	2.86	2.58	2.54	2.57	26.24	29.00	2.76	3.16	3.56	**3.85**	6X
16511				2.58	2.54	2.57	26.24						6X
16515	2.98	2.94	2.9	2.58	2.54	2.57	26.24	28.82	2.58	2.98	3.38	**3.71**	6X
16518	2.94	2.98	2.86	2.58	2.54	2.57	26.24	28.42	2.18	2.54	2.98	**3.27**	6X
16520				2.58	2.54	2.57	26.24						6X
16521	2.98	2.94	2.9	2.58	2.54	2.57	26.24	28.60	2.36	2.76	3.16	**3.49**	6X
16522	2.98	2.98	2.86	2.58	2.54	2.57	26.24	28.50	2.26	2.66	3.10	**3.39**	6X
16524	3.00	2.94	2.86	2.58	2.54	2.57	26.24	28.56	2.32	2.74	3.14	**3.43**	6X

XRFC1

timing for shots in the ddcyl series #3 (99-1) 5/11-13/99
4b.5 on 16464 and 1c.5 on 16465

shot	f1f2	f2f3	f3f4	tc12	tc23	tc34	tf1abs(	tf1	f1abs	f2abs	f3abs	f4abs	Mag
16459	0.98	0.98	0.99	0.98	0.99	0.99	28.21	28.88	0.67	0.67	0.66	**0.67**	
16464	1.22	1.31	1.22	0.98	0.99	0.99	28.21	27.36	-0.85	-0.61	-0.29	**-0.05**	2X
16465	1.20	1.30	1.22	0.98	0.99	0.99	28.21	28.04	-0.17	0.05	0.36	**0.60**	2X
16467	1.24	1.26	1.26	0.98	0.99	0.99	28.23	31.94	3.71	3.98	4.25	**4.52**	6X
16468	1.22	1.30	1.2	0.98	0.99	0.99	28.23	32.04	3.81	4.06	4.37	**4.58**	6X
16471	1.24	1.28	1.22	0.98	0.99	0.99	28.23	32.18	3.95	4.22	4.51	**4.74**	6X
16473	1.22	1.29	1.22	0.98	0.99	0.99	28.23	32.34	4.11	4.36	4.66	**4.89**	6X
16474	1.19	1.32	1.21	0.98	0.99	0.99	28.23	32.50	4.27	4.49	4.82	**5.04**	6X
16475	1.24	1.27	1.21	0.98	0.99	0.99	28.23	32.62	4.39	4.66	4.94	**5.16**	6X
16477	1.24	1.29	1.19	0.98	0.99	0.99	28.23	32.40	4.17	4.44	4.74	**4.94**	6X
16480	0.97	1.00	0.98	0.98	0.99	0.99	28.23	33.48	5.25	5.25	5.26	**5.25**	6X
16482	1.35	1.50	1.4	0.98	0.99	0.99	28.23	30.38	2.15	2.53	3.04	**3.45**	6X
16484	1.36	1.50	1.37	0.98	0.99	0.99	28.23	30.10	1.87	2.26	2.77	**3.15**	6X
16485	1.39	1.45	1.43	0.98	0.99	0.99	28.23	30.14	1.91	2.33	2.79	**3.23**	6X
16486	1.37	1.52	1.39	0.98	0.99	0.99	28.23	30.32	2.09	2.49	3.02	**3.42**	6X
16487	1.35	1.49	1.4	0.98	0.99	0.99	28.23	30.30	2.07	2.45	2.95	**3.36**	6X
16489				0.98	0.99	0.99	28.23	30.36	2.13	1.16	0.16	**-0.82**	6X
16490				0.98	0.99	0.99	28.23	30.18	1.95	0.97	-0.02	**-1.00**	6X
16491				0.98	0.99	0.99	28.23	30.32	2.09	1.12	0.13	**-0.86**	6X
16493				0.98	0.99	0.99	28.23	30.20	1.97	0.99	0.00	**-0.98**	6X
16496				0.98	0.99	0.99	28.23	30.20	1.97	0.99	0.00	**-0.98**	6X
16497				0.98	0.99	0.99	28.23	30.22	1.99	1.02	0.02	**-0.96**	6X
16498				0.98	0.99	0.99	28.23	30.34	2.11	1.14	0.14	**-0.84**	6X
16500				0.98	0.99	0.99	28.23	31.16	2.93	1.96	0.97	**-0.02**	6X
16503				0.98	0.99	0.99	28.23	29.66	1.43	0.46	-0.54	**-1.52**	6X
16506				0.98	0.99	0.99	28.23	30.60	2.37	1.40	0.41	**-0.58**	6X
16508				0.98	0.99	0.99	28.23	30.62	2.39	1.42	0.43	**-0.56**	6X
16509				0.98	0.99	0.99	28.23	30.62	2.39	1.42	0.43	**-0.56**	6X
16511				0.98	0.99	0.99	28.23	30.72	2.49	1.52	0.52	**-0.46**	6X
16515				0.98	0.99	0.99	28.23	30.60	2.37	1.40	0.41	**-0.58**	6X
16518				0.98	0.99	0.99	28.23	30.70	2.47	1.50	0.50	**-0.48**	6X
16520				0.98	0.99	0.99	28.23	30.72	2.49	1.52	0.52	**-0.46**	6X
16521				0.98	0.99	0.99	28.23	30.74	2.51	1.54	0.54	**-0.44**	6X
16522				0.98	0.99	0.99	28.23	30.68	2.45	1.48	0.48	**-0.50**	6X
16524				0.98	0.99	0.99	28.23	30.76	2.53	1.56	0.57	**-0.42**	6X