SAND2011-6920P

Abstract for a presentation- "ZBacklighter Update/Overview"
At the 8th International Laser Operations Workshop
October 3-7, 2011 Hosted by AWE UK

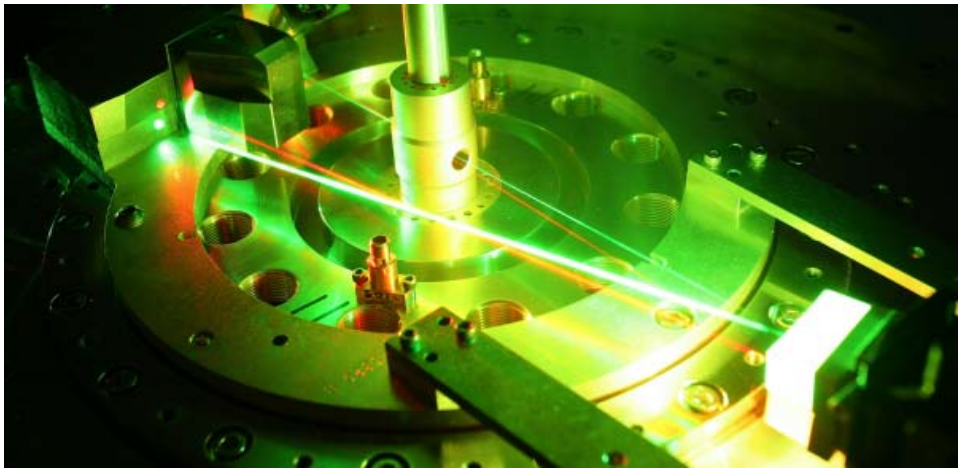
An update on the current status of the ZBacklighter facility, including progress reports on improvements to the facility and operational statistics since the 7th ILOW.

Sandia National Laboratories

ZBacklighter Update/Overview

Briggs Atherton, John Bellum, Verle Bigman, Dave Bliss, Ian Smith, Jonathan Shores, Jens Schwarz, Mark Kimmel, Patrick Rambo, Matthias Geissel, Marius Schollmeier, Mark Vargas, Damon Kletecka, Jimmy Potter, Robin Broyles, Joanne Wistor.

8th International Laser Operations Workshop
October 3-7, 2011

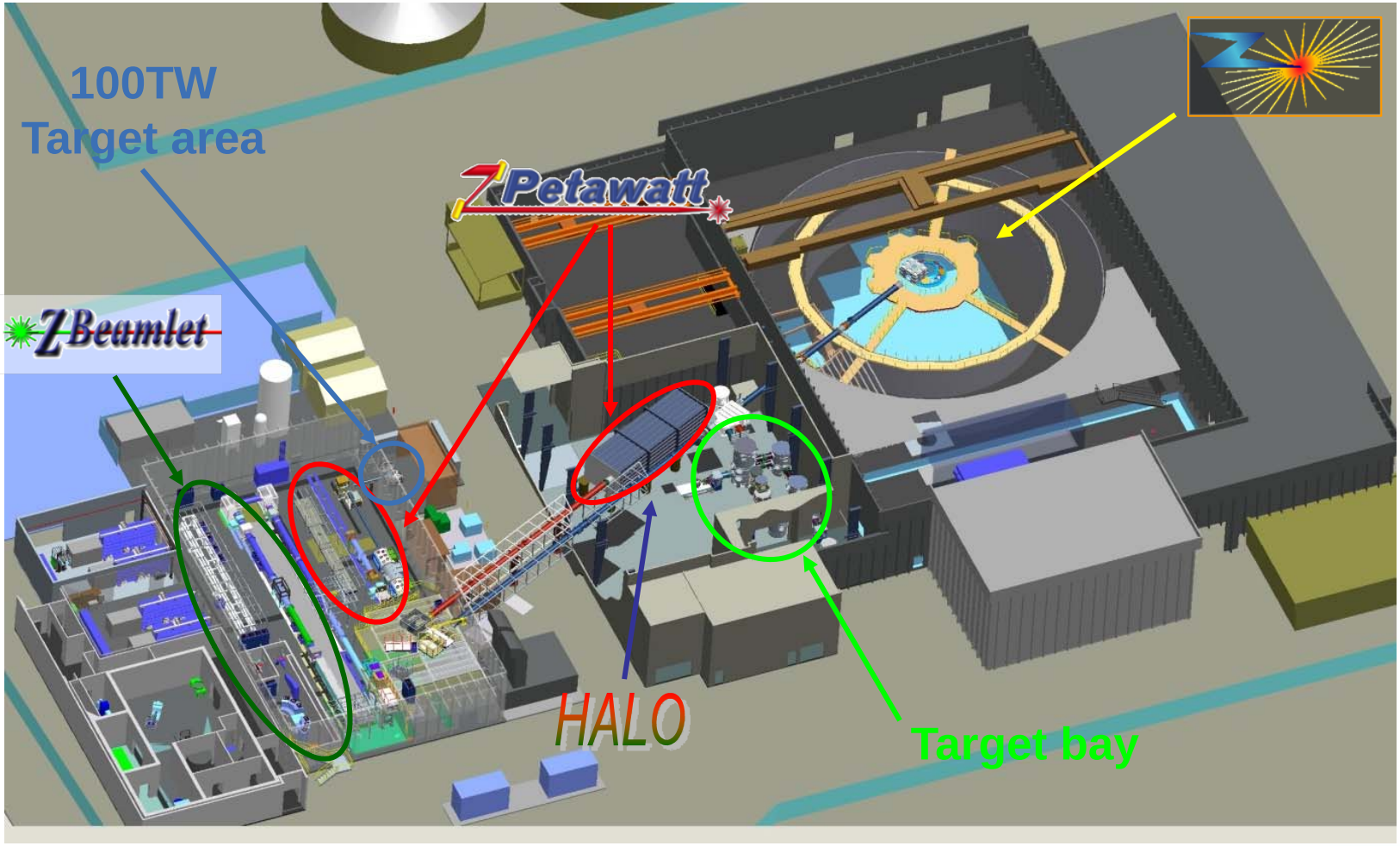


ZBacklighter

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Sandia National Laboratories

Facility Overview



Sandia National Laboratories

What's New- Target Bay

• For 7th ILOW the ZPetawatt compressor had been commissioned and was operational.

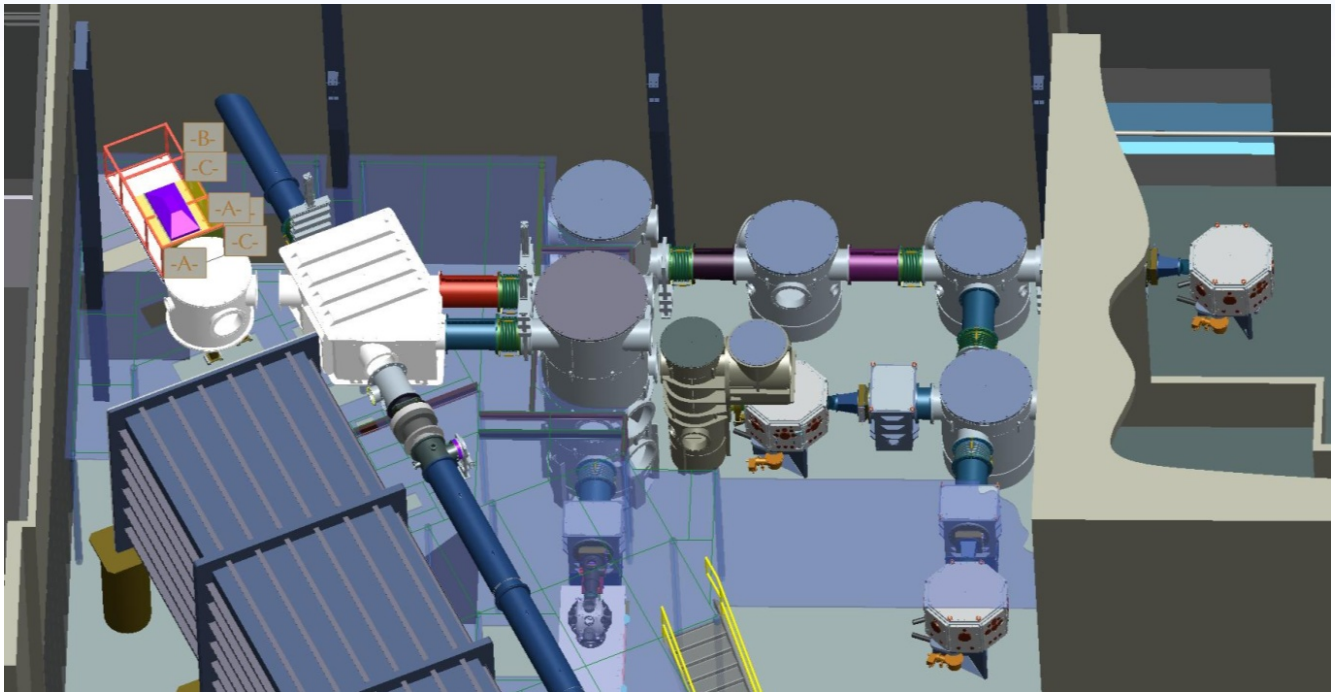
•What had been the old “Phase C” of the Z building was mainly a feed through from the laser bay to the Z accelerator. The next step was to turn it into the Target Bay.

•The original ZBeamlet Calibration Chamber had been relocated from the laser bay.

Sandia National Laboratories

What's New- Target Bay

- The plan was to create a multi chamber target area to allow several experimental teams to be working on setup or experiments simultaneously for more efficient use of the available laser systems.



- There are 4 target chambers shown above, the central ZPetawatt chamber and 3 chambers for ZBeamlet.

- There is a 5th small chamber for the HALO system underneath the ZPetawatt compressor.

- ZBeamlet and ZPetawatt can be combined, opposing or orthogonal in the ZPetawatt chamber with a roving final focusing assembly (FOA). Either ZBeamlet or ZPetawatt can be transported to Z.

Sandia National Laboratories

What's New- Target Bay

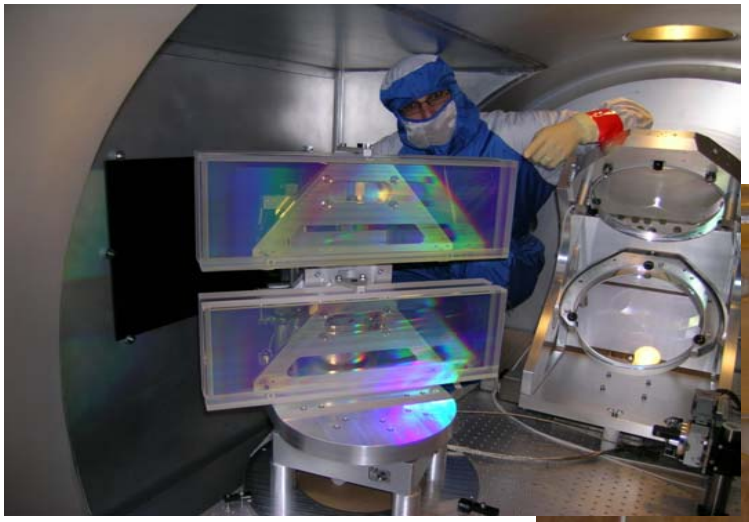
• The target by is now mostly complete, the large hardware is installed and the small Z Beamlet chamber is routinely used. Mirrors, focusing lens and target positioner need installing to bring the new large chamber online for Z Beamlet.

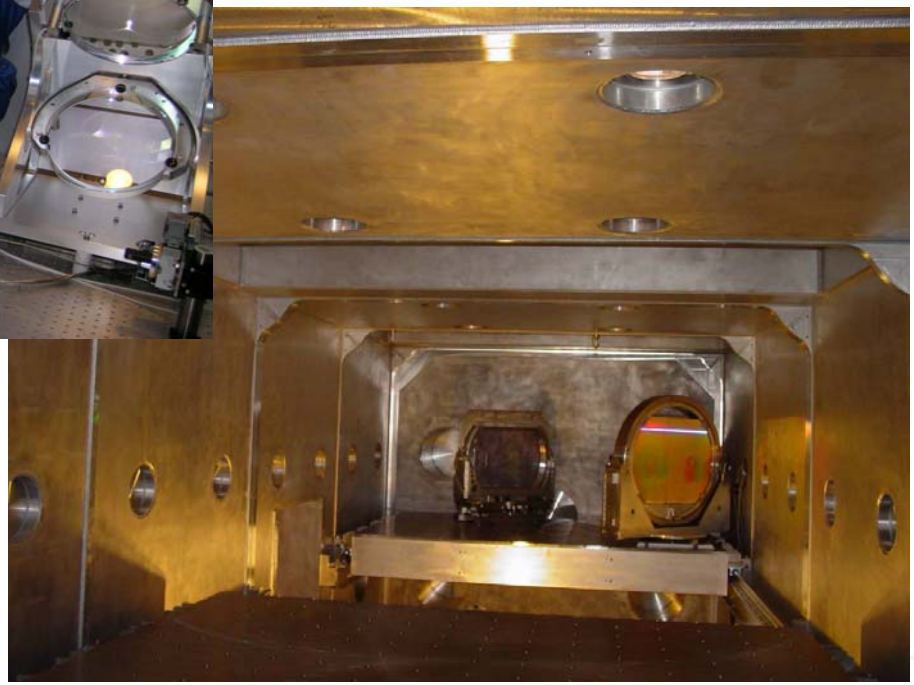
•The parabolas for the Z Petawatt chamber have arrived but need coating.

Sandia National Laboratories

What's New- Short Pulse Laser Systems

- For the 7th ILOW the 100TW vacuum compressor was upgraded with 1740l/mm MLD's from PGL (4@60cmX21cm, AOI=72°, θ_{diff}=62°, L_{double}=2.24m separation).
- This was the 2nd mile stone in the MLD development plan.



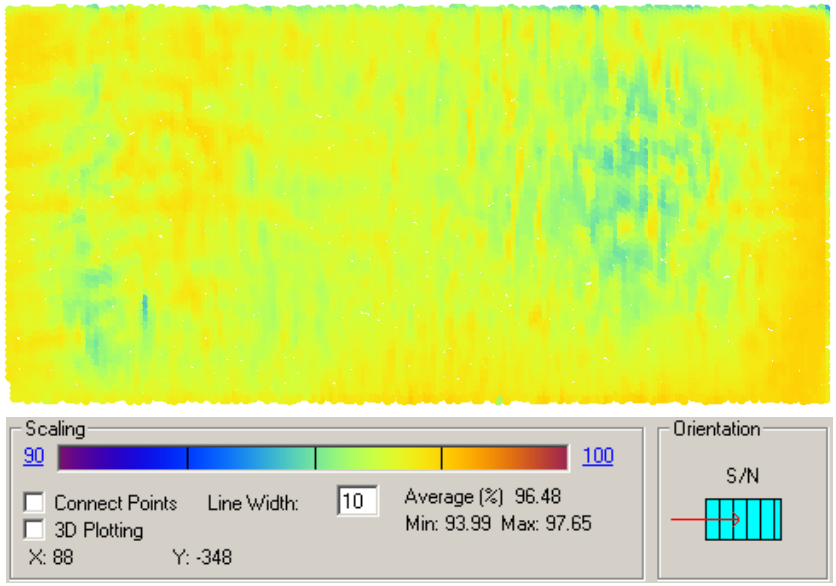


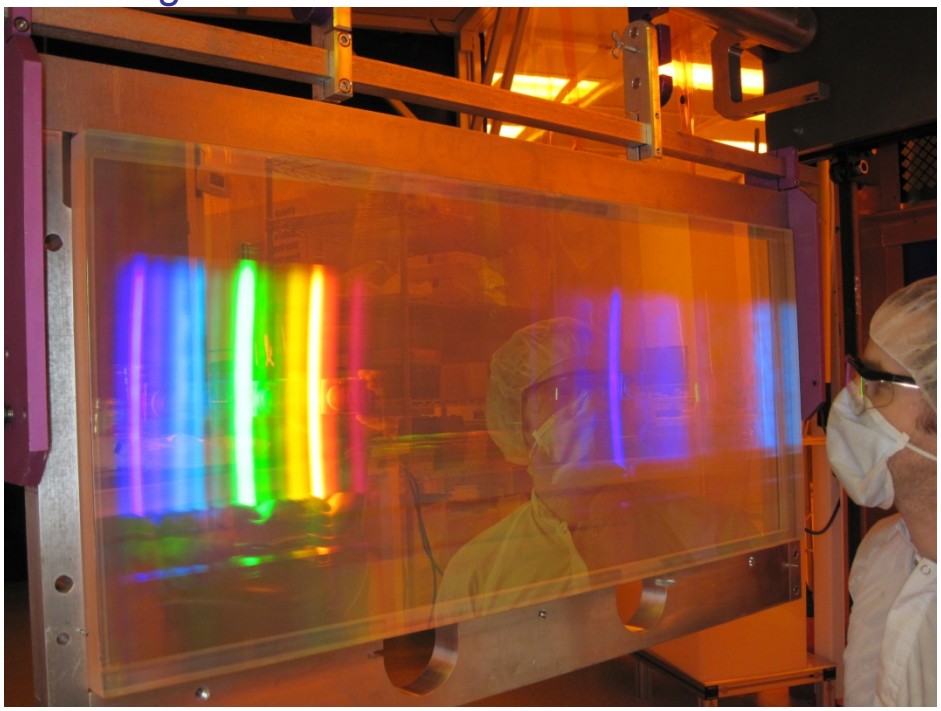
- The ZPW compressor was reapplying the NOVA gold gratings

Sandia National Laboratories

What's New- Short Pulse Laser Systems

- We now have four 94cm x 42cm, 1740l/mm multi layer dielectric (MLD) gratings from PGL (Sandia coatings) with required damage threshold of:
  - >1 J/cm^2 in the RHs at 500fs
  - >3 J/cm^2 in the RHs at 10ps





Diffraction efficiency in 1st order >96%

- To take advantage of the potential of the full scale MLD grating we need to expand the beam size of the main amplifier section of Z Petawatt. This expansion was part of the original design and the main hardware was build big enough to take the larger optics. With the MLD development being successful the expansion is now a project for the coming years.

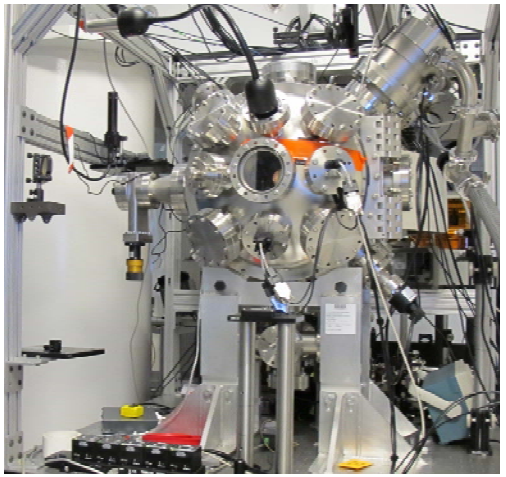
Sandia National Laboratories

What's New- NLS Upgrade to HALO

• FY-11 experiment proposals called for large numbers of Z Beamlet shots but needed only low energy. This prompted a upgrade of NLS (diagnostic probe for ZBL) to a fully capable target shooter in its own right. This included higher energy, diagnostics, improved beam and focal quality, AWG pulse shaping and improved target positioning and alignment systems.

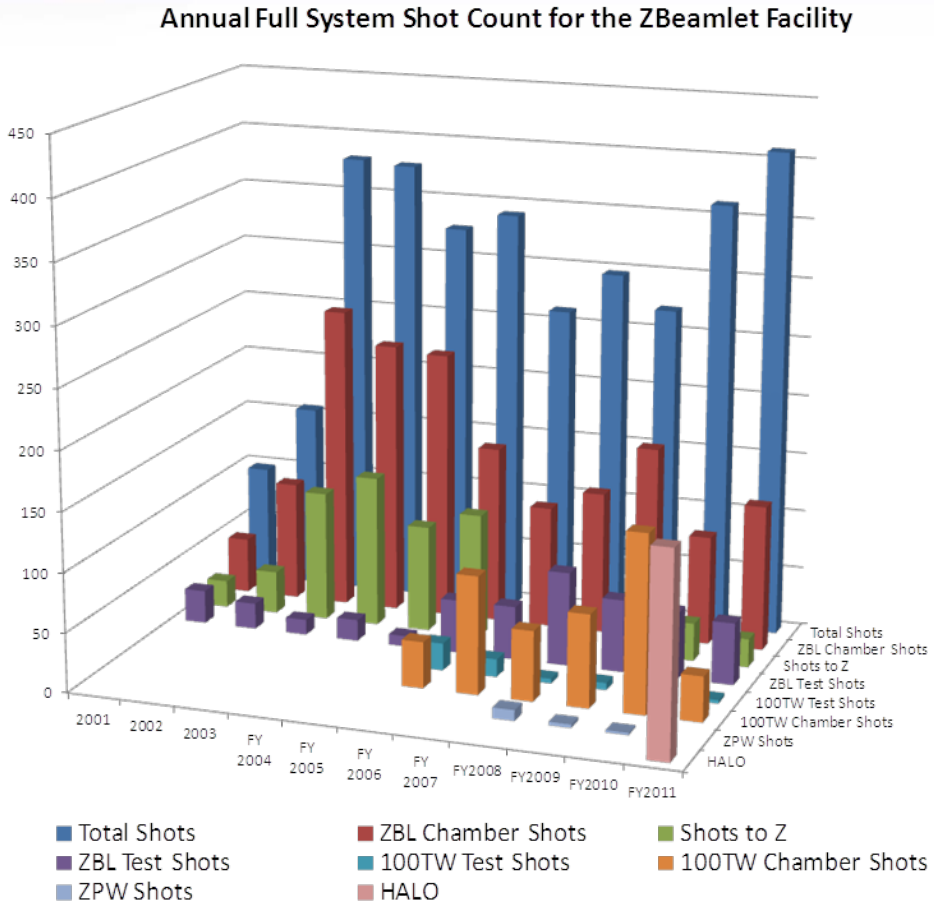
•The effort resulted in 169 HALO experimental shots in the later half of FY-11. Allowing 81 experimental shots for UXI development compared to the 26 UXI shots that were achieved on Z Beamlet in the first half of FY-11.

•Other experiments benefiting form the high shot rate (10-20 min turn round) included 65 shots for SPIDER streak camera characterization and 23 shots on shocked meteorite samples.



Sandia National Laboratories

Z-Backlighter Facility Shot Statistics



- The HALO upgrade directed effort away from the short pulse systems (Z Petawatt and 100TW) and their shot numbers are significantly down this year. However the HALO system has added significantly to the over all amount of experiments.

- Z Beamlet shots supporting Z experiments are quite low this year reflecting a Z schedule that contains many material property shots that do not utilize backlighting.

- Z Beamlet's own experiments numbers are similar to recent years but include significantly more scientific content.

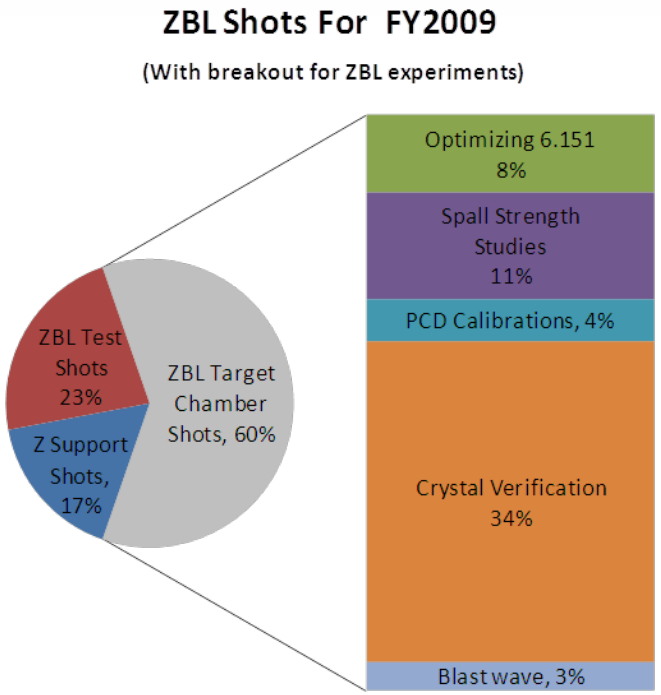
Sandia National Laboratories

ZBacklighter Users

- As previously reported at the 7th ILOW meeting 34% of ZBL shots were being used for crystal verification. Typically when Z Beamlet supports Z experiments the two frame bent crystal imager is used and both crystals are destroyed on the shot.

- Initial experience showed that each crystal had to be verified (bias angle and field of view checked) with Z Beamlet shots and had a 30% rejection rate.

- We developed a “offline” verification capability (DC x-ray source) that could process the crystals and free up the Z Beamlet schedule.



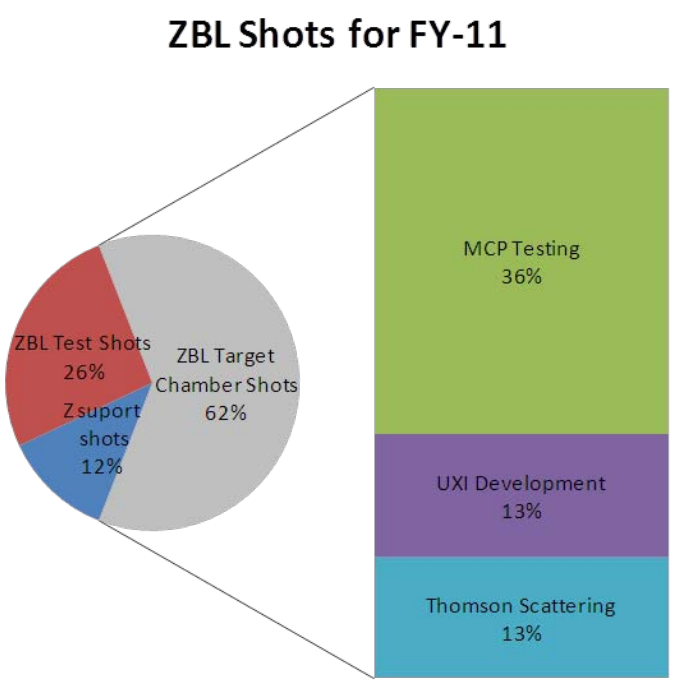
Sandia National Laboratories

ZBacklighter Users

• The crystal verification shots have effectively been replaced with true user experiments.

•In FY-11 all the users have been internal Sandians developing diagnostics for implementation on Z experiments.

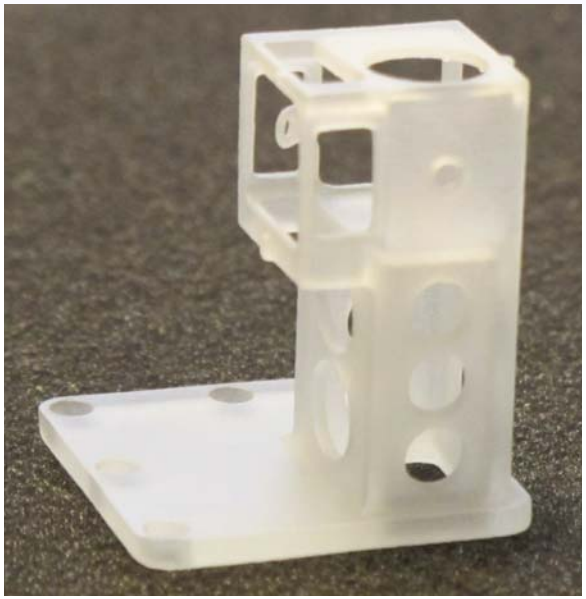
- •The micro channel plate (MCP) work is developing a gated MCP to cut down on time integrated background on the crystal imager system. The system is currently scheduled to be fielded on Z on Oct 7th.
- •The UXI experiments are a longer term solution to the same problem of temporal gating and framing but also detecting the x-rays directly.
- •The Thomson scattering work is developing detectors and scattering geometries to utilize Z Beamlet as a source for a x-ray scattering based diagnostic on Z-experiments.



Sandia National Laboratories

ZBacklighter Users

•The Thomson scattering diagnostic is being developed for material science experiments on Z. There are several interesting operational aspects to the work.



• If successful it will introduce ZBeamlet's use to a large class of Z experiments that currently do not use our support.

•So far the development work has concentrated on characterizing the instruments, the source spectrum and the spectrum scattered from a cold material. The next stage will include measurements from heated material. The heating will done with the 2nd beam of the Z Beamlet MFB system and will be the first 2 beam experiment for the target area.

•The targets have several features that have to be aligned relative to each other,
- •The x-ray source foil
- •The heating beam conversion foil
- •The sample material, and field of view apertures

•In the past this has lead to a complex and time consuming setup. The next series of experiments utilize a monolithic fixture to hold all the components that simply glue into place. The fixtures are "3d printed" directly from CAD designs with 100μm tolerances, cheaply enough to be single use and disposable ($60).

Sandia National Laboratories

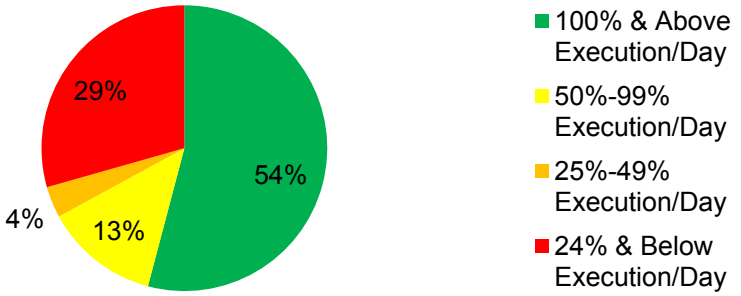
2nd Thought on Shot Statistics

• Over the years the number of shots has been the primary statistic for the performance of the facility however this is often influenced by external factors like the Z schedule and the complexity of the experiments. Also the various systems have intrinsically different shot rates, 1/day for Z, 3 per day for Z Beamlet and 4/hour for HALO

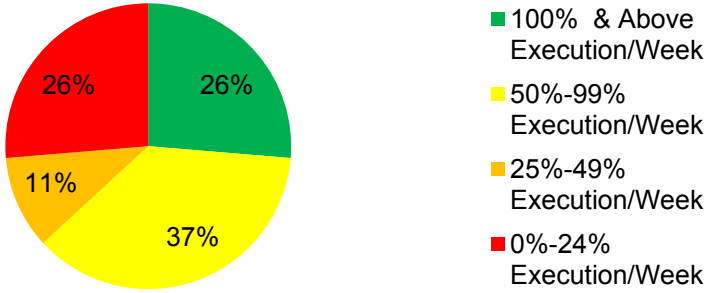
•Recently we have been considering the concept of execution efficiency, how effectively do we execute the planned shots. Along these lines the plots show the % of the planed shots that are actually completed.

•The plots consider two time scales. The long term scale compares actual shots to the Z Beamlet schedule (considers 1 week time slots over the coming year). The short term scale compares actual shots to the "daily report" that contains a shot plan for the next day.

Execution of Day to Day Planning



Execution of Long Term Planning



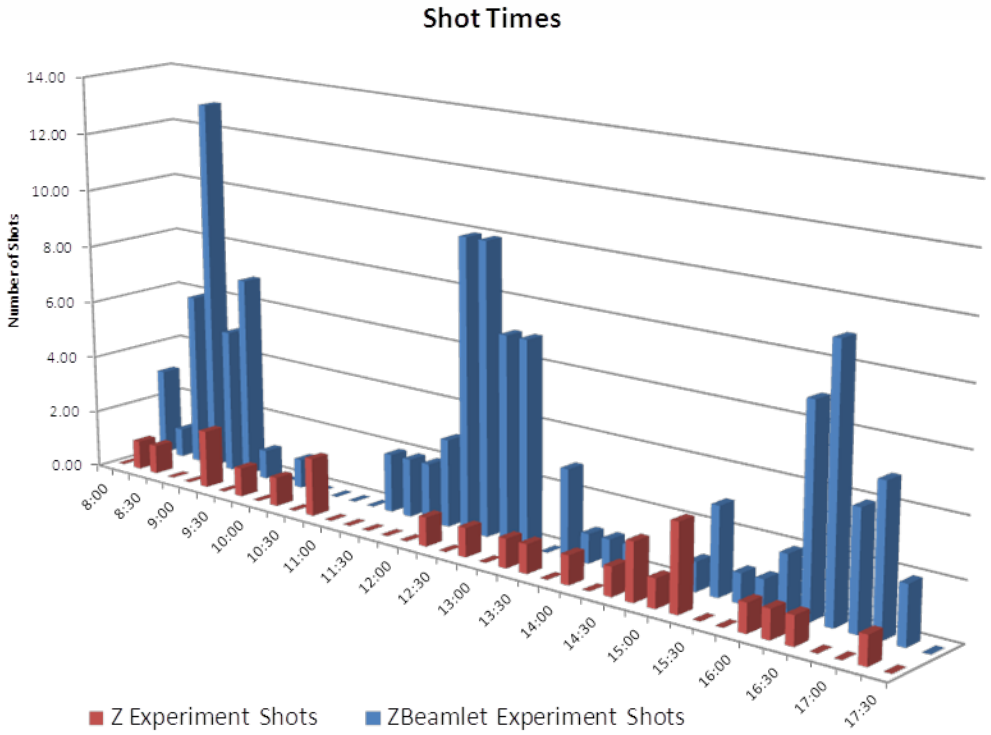
Sandia National Laboratories

2nd Thought on Shot Statistics

• In the last year we have changed operational philosophy on shot times. Previously we have shot as soon as we are ready as often as possible. This approach was good for maximizing the number of Z Beamlet shots, however this had a negative impact on other work going on in the facility in that it was unpredictable when the lab was going to be cleared for a ZBeamlet shot.

•We have now moved to a “shot window” mode that defines 3 one hour periods a day when Z Beamlet shots will be fired (doesn't include Z support shots).

•79% of Z Beamlet experimental shots now occur within the 3 standard shot windows, 8:00-9:00, 12:00-1:00 and 4:00-5:00 (±10 min tolerance, urgent trouble shooting not included).



Sandia National Laboratories

Conclusions

- Developed large MLD grating for the next level of short pulse operation.

•Recognizing our output is limited by staffing levels, we have concentrated on improving working efficiency.

- The new multi-chamber target area is nearing completion. Multi chambers should allow efficient use of the main lasers potential by allowing experiment set up to be off the critical path.

•We have a tiered structure, matching smaller scale experiments with smaller high rep-rate lasers (ZBeamlet, Z Petawatt, 100TW, HALO and short pulse damage tester).

•We have eliminated some non-experimental work load (crystal verification).

•Modified working practice (shot windows) allows the operations of several lasers to “mesh” with less interference.

Back up slides

Sandia
National
Laboratories

ZBeamlet Performance in Support of Z Experiments

	Shot Numbers		Energy (J)		Timing (ns)			Successful Images		
Experiment	Z#	ZBL#	Main	2nd	1st frame time	error	Interframe	Main	2nd	Notes
Sierra A0112C	2145	B10120904						×	×	1
Cibola Test		B10122202	966	703				✓	✓	7
Cibola A0145		B11010402						✓	✓	8
Cibola A0145	2149	B11010607	1070	856	3074.9	0.4	1.9	✓	✓	2
JetPac A0133	2150	B11011105	1365		3175.7	0.65		✓		
JetPac A0133	2151	B11011202	1662		3309.6	-0.4		×		3
JetPac A0133	2152	B11011402	1751		3290.6	0.6		×		4
Sierra A0112	2161	B11020808	1171	741	3077.2	0.2	15.1	✓	✓	
Cibola A0145	2162	B11020903	1219	1015	3074.8	0.8	2.0	×	×	5
Cibola A0145	2163	B11021105	1330	960	3076.9	0.9	2.0	✓	×	6
Lincoln A0152	2172	B11030108	1511	953	3117.2	-0.3	3.6	✓	✓	
Lincoln A0152	2173	B11030204	1087	1019	3122.3	0.5	2.4	✓	✓	
Lincoln A0104	2174	B11030310	1180	866	3111.2	0.1	6.8	✓	✓	
Sierra 5 A0139	2177	B11031102	986	616	3077.1	0.1	15.0	✓	✓	
Cibola 4 A0157A	2190	B11050303	778	692	3065	-1	2.0	✓	✓	9
Cibola 4 A0157B	2191	B11050410	1136	1054	3069.8	-0.2	2.0	✓	✓	9
Cibola 4 A0157C	2192	B11050512	1294	1133	3070.1	1.1	4.2	✓	✓	9
Union A0166A	2207	B11060702	1189	1086	3036.2	0.2	4.0	✓	✓	
Union A0166B	2208	B11060805	1139	1059	3048.1	0.1	4.0	✓	✓	
Union A0166C	2209	B11060905	1035	1063	3050.3	-0.7	2.0	✓	✓	
Union A0166D	2210	B11061004	1171	1082	3045.2	0.2	8.0	✓	✓	
Cibola A0157E								N.A.	N.A.	10
Cibola A0157E	2211	B11061405	1036	1058	3067.2	0.7	3.0	✓	✓	
Cibola A0157F	2212	B11061507	1202	1169	3067.1	-0.9	3.0	×	×	11
Cibola A0157D	2213	B11061607	1222	1156	3064.6	-0.9	3.0	✓	✓	
Otero A0153A	2214	B11062004	1866		3043.4	0.4		✓		12
Otero A0153B	2215	B11062106	1282		3037	1		✓		13
Otero A0153D	2217	B11062404	1495		3042.3	-0.7		✓		
Sierra A0178A	2249	B11090706	1104	973	3061.5	-0.5	15.0	✓	✓	
Union A0148A	2250	B11090803	1194	963	3049.7	1.1	3.1	✓	✓	
Cibola A0157G	2251	B11090904	1247	1026	3069.88	-0.1	3.1	✓	✓	

Z Shots Supported-	28	Mean-	1239	966	Mean-	0.1	**Reliability-**	**83%**	**83%**	(Successful images from shots)
ZBL Shots Requested-	31	σ-	19%	16%	RMS error-	0.6	Availability-	97%	96%	(Shot when requested)
ZBL Shots Supplied-	30	>1200 J-	46%	0%			Return rate-	81%	80%	(Successful images from all requests)
		1200J±15%	71%	45%						

Notes

1- ZBL only Pilc'ed due to a blown power supply in the Z permissive fiber sender unit.
2- Viable images, high background and lower signal on 2nd. ZBL delayed this shot, the following shot was cancelled due to rad hold.
3- Faint image of fidu on top of low uniform background.
4- Uniform high background. Implosion time for the shot 50ns early.
5- High background on both frames. The shot had a exceptionally long radiation hold. IP was in the machine for 17 hours.
6- 2nd image had low signal and high background. The shot had a long radiation hold (weekend) the IP was in the machine for 64 hours.
7- Backlighting test on a surrogate grid target in Z.
8- Preshot radiograph, Diagnostics did not work but target images were successful.
9- New IP filter pack used, extra attenuation at <1.5keV
10-PEPC switch tube failed on timing check, delayed shot to the next day.
11- High background on both images with defined sharp edges.
12- Some high localized background, identified as the view of B-dots around the right side (plan view) of the aperture block.
13- Extra tungsten block added to block the B-Dot view

Sandia National Laboratories

ZBeamlet Performance in Support of Z Experiments

	Shot Numbers		Energy (J)		Timing (ns)			Successful Images		
Experiment	Z#	ZBL#	Main	2nd	1st frame time	error	Interframe	Main	2nd	Notes
Luna 2	2007									1
Luna 2	2008									1
Luna 2	2009									1
SWP 291		B9121005	1013	865			22.1	×	×	2
SWP 291		B9121017	1021	871			22.1	✓	✓	
SWP 291		B9121104	909	847			22.1	✓	✓	
SWP 291		B9121116	805	748			22.1	✓	✓	
SWP 291		B10011105	829					✓	×	3
Otero 2	2039	B10012706	1120		3061.3	1.3	N.A.	✓		
Otero 2	2040	B10012804	1008		3029.8	-0.9	N.A.	✓		
Otero 2	2041	B10012905	1012		3078.8	1.1	N.A.	✓		
Facility	2047	B10020810	981	728	2899.7	-0.3	22.1	✓	×	4
Facility		B10020904	1294	1027			22.1	×	✓	5
Taos	2057	B10022205	1293	1120	3047.75	-1.3	10	✓	×	6
Lincoln 2	2058	B10022304	1128	954	3382.65	0.55	6.9	×	×	7
Taos	2059	B10022505	1106	1126	3048.7	-0.3	10.1	✓	✓	
Lincoln 2	2060	B10022605	1121	1108	3078.35	-0.7	15	✓	✓	
Taos	2061	B10030103	1167	1229	3048.3	-0.1	10	✓	✓	
Lincoln 2	2062	B10030207	1357		3064.6	0.6	N.A.	×		8
Taos	2063	B10030304	1313		3085.1	1.1	N.A.	✓		
Lincoln 2	2064	B10030406	1101		3064.7	0.7	N.A.	✓		
Taos	2065	B10030503	1188		3084.5	0.5	N.A.	✓		
SWP 291		B10040703	934	1097			10	✓	×	9
SWP 291		B10040802	917	1100			9.9	✓	×	9
SWP 291		B10040804	929	1109			10	✓	×	9
SWP 291		B10040810	1004	1201			10	✓	×	9
Sierra	2101	N.A.						N.A.	N.A.	10
Lincoln	2102	B10052807	1092		3039.8	-0.5		✓		11
Lincoln 3	2104	B10060309	904	754	3048.9	-0.3	7	✓	✓	
Lincoln 3	2105	B10060410	909	1017	3100.3	0.2	7	✓	✓	
Lincoln 3	2106	B10060705	849	1013	3112.7	0.7	5	✓	✓	
Lincoln 3	2107	B10060804						×	×	12
Union 1	2108	B10061604	1157	1197	3035.6	-0.4	14	✓	✓	
Union 1	2110	B10061807	1139	1106	3025.3	-0.1	18	✓	✓	13
Cibola 2	2115	B10062804	750	850	3073.4	0.4	2.1	✓	✓	
Cibola 2	2116	B10062906	1112	1003	3071.1	0.1	1.9	✓	×	14
Cibola 2	2117	B10070104	1068	1385	3073.1	-0.9	1.9	×	×	15
Cibola 2	2118	B10070204	1164	1508	3073	-1	4	✓	×	14,16

Z Shots Supported-	24	Mean-	1051	1040	Mean-	0.0	**Reliability-**	**82%**	**50%**	(Successful images from shots)
ZBL Shots Requested-	35	σ-	14%	19%	RMS error-	0.7	Availability-	97%	96%	(Shot when requested)
ZBL Shots Supplied-	34	>1200 J-	12%	17%			Return rate-	80%	48%	(Successful images from all requests)
		1200J±15%	55%	46%						

Notes

1- ZBL dropped from the shots due to high leak rate of Z center section.
2- Image blocked by target.
3- TSF pinhole misalignment due to residual error on the encoder following a recovery from a power failure the previous day.
4- MCP detector failed to trigger correctly due to noise.
5- Very week image from main beam believed to be due to the target foil detaching during pump down. Shot was changed to a pre-shot radiograph.
6- Both images had some apparent clipping, at the limiting aperture.
7- An error was made in the timing calculation that put the timing request off by 332.9ns. The error entered above is relative to the incorrect setting to allow the assessment of jitter verses drift. Two good images were obtained but not at a useful time.
8- An error in transcribing bias measurement data into the crystal data base (loosing a -ve sign) caused the bias alignment mark to be incorrectly placed on the aperture plate, in tern causing the imager to be misaligned.
9- Timing shots for Gated MCP development. IP on main frame, MCP on 2nd. Timing was not successful.
10- Rod bank problem caused a swap of adjacent shot days and dropping ZBL from this shot.
11- The rod bank problem, as above, caused a swap of adjacent shot days to allow a day for repairs.
12- Z prefired into diverters with about 10s to go on the countdown and aborted ZBL main bank triggers.
13- A new measurement of the offset between the ZBL Beat reference and TZn was implemented between the two Union 1 shots
14-Unexplained high background levels on the second frame
15-Unexplained high background on 2nd frame and clipping on 1st.
16-Diode data unusable, energy split based on the ratio of the previous shot .

Sandia National Laboratories

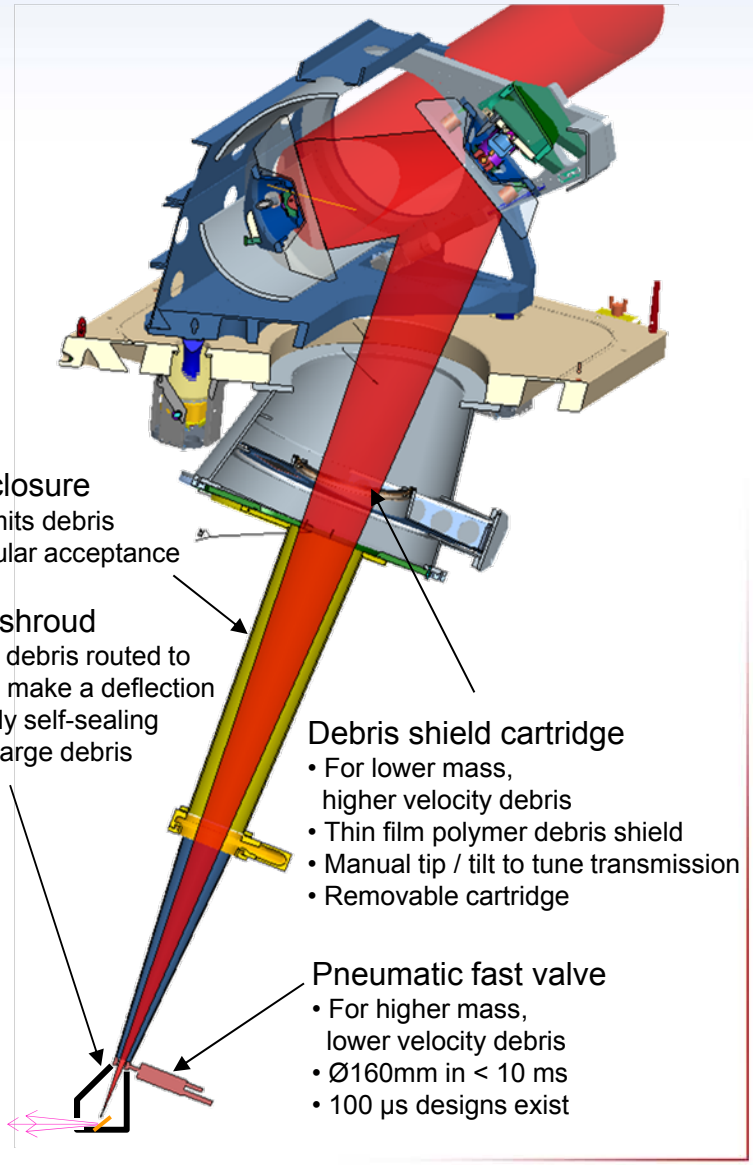
Debris mitigation at the FOA

- Debris is generated from laser target interactions (minor) and z-pinch (major) sources to yield a distribution of fast and slow debris (<1 to 25km/s).

- Terawatt/nanosecond scale backlighting deals debris via debris shields (30X30X1cm^3)

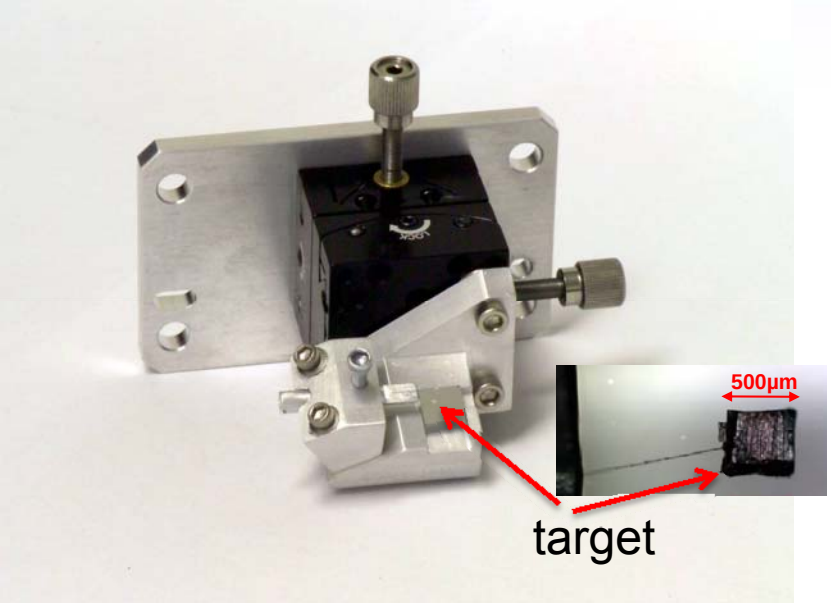
- Petawatt/picosecond scale backlighting must deal with debris differently due to B-integral:
  - Thin polymer film shields (passive)
  - Intelligent optics enclosure design
  - Fast debris shutters (active)

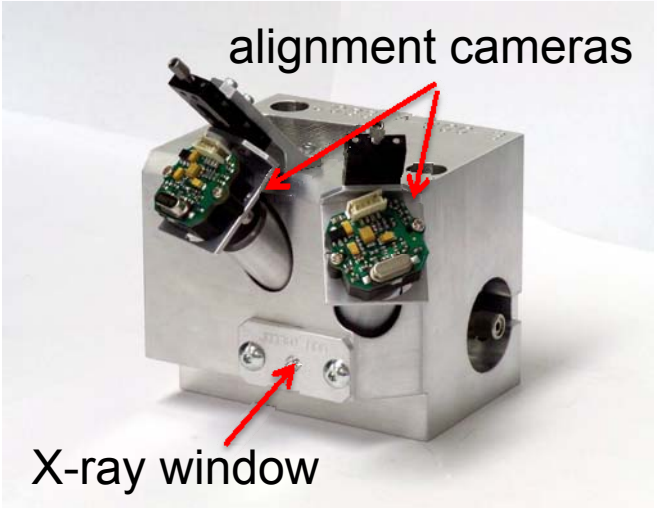
- The new ZPW FOA will be compatible with ZBL, improving ZBL's flexibility by eliminating hardware conflicts with the Z axial diagnostics package.



Sandia National Laboratories

25 keV Laser Target for Z



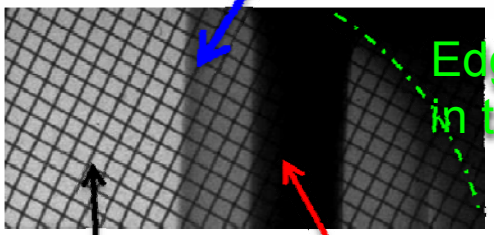


A box with two microscope-CCD cameras was developed to hold the target while allowing precision alignment and debris protection.

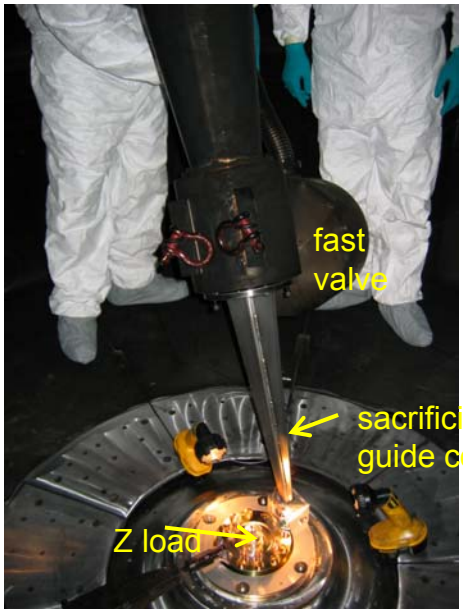
The X-ray window was chosen to be a combination of mostly Be and Kapton.

1st 25 keV radiograph in Z

'Lincoln' aluminum liner, 2x magnified



contact radiograph of copper mesh



Inside of Z, Z-Petawatt is fully enclosed in a metal casing. The tapered beam tube ends in the debris box with the target. A fast valve acts as 2nd line of defense against heavy debris.

The top anode assembly for the Z load was removed for this picture.

Prototype steel box for debris protection after a Z shot

Sandia National Laboratories

ZPW/100TW shots for 2010

Experiment	# Shots
PW cal shots	14
100TW cal shots	10
proton acceleration shots	52
25keV x-ray development	37
PW preshot radiograph	2
AR k-alpha, UCLA collaboration	4
TU Darmstadt proton work	8
Bremsstrahlung radiography Tim Webb	18
Ellipsiodal plasma mirror Osaka	10

ZPW/100TW Shots for FY-11

Experiment	# Shots
100TW/PW cal shot	3
High energy Bremsstrahlung radiography (Tim Webb)	14
Proton acceleration shots	24

ZBL Shots for FY-11

	Cal Chamber	Z	Grand Total
MFB Balance	2		2
Optic Conditioning	17		17
1w crosscal	27		27
2w crosscal	6		6
MCP Test	72		72
UXI	26		26
Thompson scattering	25		25
Sierra		3	3
Jet Pack		3	3
Otero		3	3
Cibola		11	11
Union		4	4
Grand Total	**175**	**24**	**199**

ZBL Shots for FY-10

	Cal Chamber	Z	Grand Total
Cibola 2		4	4
Union 1		2	2
Lincoln 3		3	3
Otero 2		3	3
Facility		2	2
Toas/Lincoln 2		9	9
MCP Test	20	9	29
Optic Conditioning	17		17
Crystal Cal	6		6
Optimizing 6.151	1		1
1w Cross Calibration	17		17
2w Cross Calibration	22		22
XRTS	17		17
uxti	48		48
Grand Total	**148**	**32**	**180**

Sandia National Laboratories