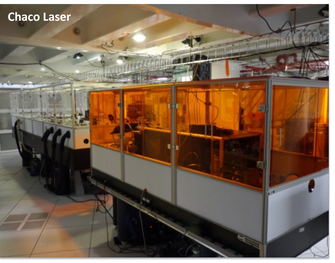
SAND2015-2016C

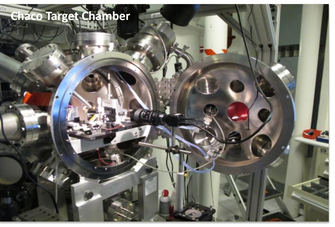
Activation of the Target Bay at Sandia's Z-Backlighter Laser Facility

M. Kimmel, P. Rambo, J. Schwarz, I.C. Smith, M. Geissel, M. Schollmeier, S. Lewis, Q. Looker, J. Shores, C.S. Speas, L. Ruggles, J. Stahoviak, and J.L. Porter

Sandia National Laboratories, Albuquerque, NM 87185, USA



Z Backlighter



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Overview

- Sandia National Laboratories operates several large lasers as part of the Z-Backlighter Facility, which has as its primary mission the radiography (or "backlighting") events on the adjacent pulsed power Z-Machine.
- Regarding high energy laser systems, the facility includes the Z-Beamlet laser (ZBL), the Z-Petawatt laser (ZPW), and the Chaco laser.

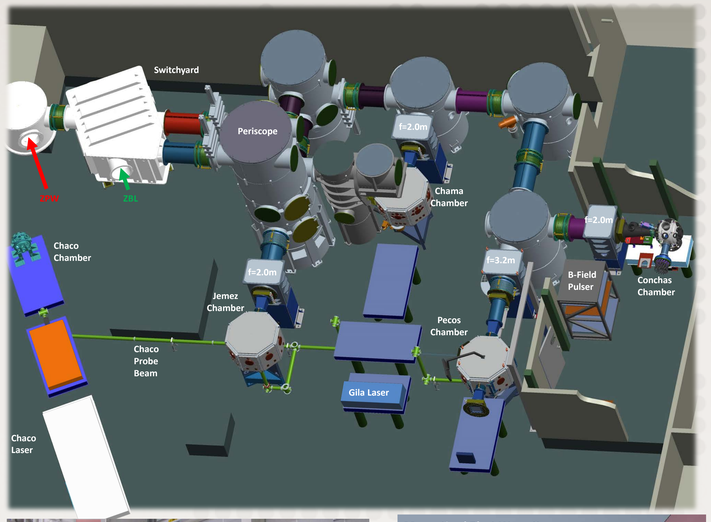
Z Backlighter

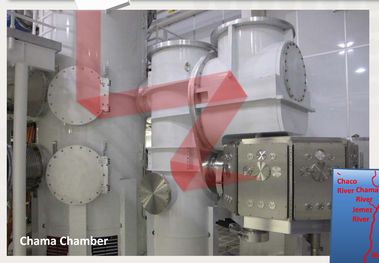
	Z Beamlet	Z Petawatt	Chaco
l (nm)	527	1054	1064 (532)
t	0.3-8 ns, typ. 2 ns	500 fs – 10 ps	300 ps – 10 ns
typ. Spot size (μm FWHM)	75	6	20
E_{max} (J)	4000	100 (200TW) / 500 (ZPW)	50 (25)
I (W/cm²)	~ 10^{17}	~10^{20}	~ 10^{16}
Shot Intervals (minutes)	180	180	20
'Special feature'	2 pulse MFB (2 frame/2 color)	CPA probe beam (< 20 mJ)	8-10 ns option: 1w and >100J (pending)

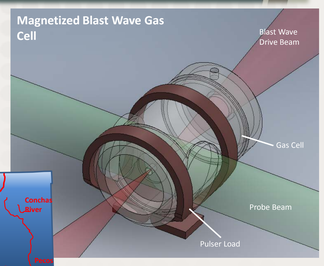
- Due to a lower shot rate on the Z-Machine than on the lasers, the Z-Backlighter lasers can support additional shots into stand-alone target chambers. In recent years, with renovated space available from the ZPW upgrade, a new Target Bay has been under development. Since ZBL and ZPW can provide up to 3 shots per day without any active cooling, the beams can be routed to multiple target chambers to reduce the schedule impact of experimental setup/takedown time.

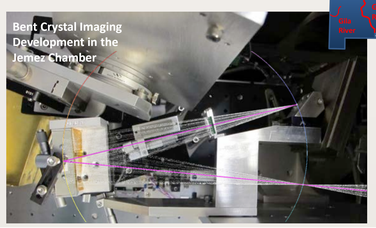
- In the Target Bay, 5 laser target chambers (named for New Mexico rivers) for HEDP interactions exist with various current or planned applications:
  - Jemez: ~ 1.5m Octagonal chamber used for ZBL /Chaco Laser
    - Applications: Backlighter/ x-ray source development and optimization
  - Pecos: ~ 1.5m Octagonal chamber used for ZBL /Chaco Laser
    - Applications: Magnetized Liner Implosion Fusion (MagLIF) coupling, Blastwave studies, x-ray source development
  - Chaco: 60cm spherical chamber used for Chaco Laser only
    - Applications: UXI development, Soft-xray calibration and testing
  - Chama: ~ 1.5m Octagonal chamber (incorporating local shielding) used for ZPW/ZBL /Chaco Laser
    - Applications: Various multi-beam interaction experiments
  - Conchas: 80cm spherical chamber used for ZBL only
    - Applications: Magnetized blastwave studies

- Transport is via evacuated beamtubes to mitigate SRS and B-Integral effects.





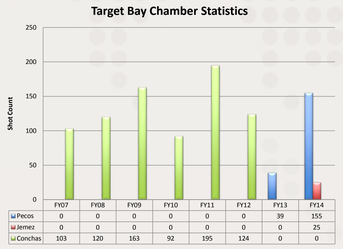




Activation Schedule

- The Target Bay construction completed in 2007, with numerous subsequent efforts:
  - The Chaco chamber was installed in 2007 and remains active.
  - The Conchas chamber (pending re-activation in 2015) was formerly the ZBL calibration chamber, the sole ZBL stand-alone target chamber until 2013. It operated from 2001 to 2006 in the adjacent Laser Bay and from 2007 to 2013 in the Target Bay.
  - Regarding the newer octagonal chambers, the Pecos chamber was activated in mid-2013, followed by Jemez in mid-2014. Chama is pending activation in 2015. These chambers add capability and internal space unavailable previously with the calibration (Conchas) chamber.
  - The Chaco Laser hardware dates from circa 1990 and was installed in the Target Bay upon completion of construction in 2007. A major update to a modern front-end and relay-imaged amplification occurred in 2010-2011. Multiple pulse aspects were incorporated in 2013-2014. The offshoot Gila laser was implemented in 2014.

Shot Statistics



- Multiple target chambers eventually should ease target area conflicts and enhance productivity (until limited by laser operations).
- Data for FY14 indicates that the combined large chamber shot performance is at a level comparable to the highest ones from the previous years with the single calibration chamber (now Conchas).

B-Field Pulser

- Under a collaboration with the University of Texas, a B-field pulser was constructed to examine laser-matter interactions under high magnetic fields. The system hardware delivers a high current (100kA per cap) electrical pulse through cables and a transmission line vacuum power-feed to a load for creating a short (~1μs) and intense (>10T) magnetic field for laser experiments.

- The vacuum power-feed will primarily be on the Conchas chamber for testing of magnetized blastwaves in the 10 to 30T range. Due to similarities to the applied magnetic field on MagLIF experiments on Z, the power-feed can be placed on the Pecos chamber for related MagLIF experiments.

Chaco and Gila Lasers

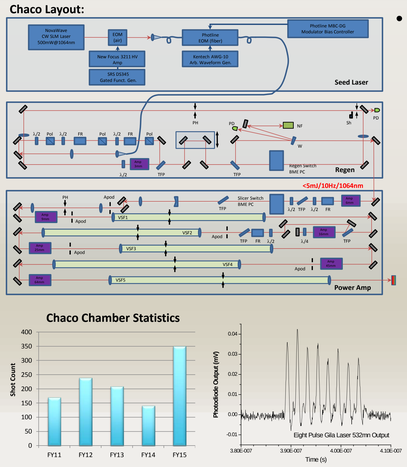
- The Chaco laser was developed as both a soft x-ray calibration source and as a probe beam for laser-matter interactions in the larger chambers. Shot rates run from 5 to 15 minutes (depending on which amplifiers are active), which allows up to 60 shots per day.

- The laser architecture is very similar to that of ZBL except that Nd:YAG and Nd:Silicate glass are used as the gain media. The architecture includes: a stable single longitudinal mode oscillator, a precise electro-optic pulseshaper driven by an arbitrary waveform generator (allowing tunable pulsewidths and shapes from 0.2 to 8ns), an ultra-stable DPSS Nd:YAG regenerative amplifier, and successively larger Nd:Silicate rod amplifiers (up to 64mm diameter) . Frequency conversion to 532nm is performed to mitigate target back-reflection hazards in the Chaco interaction chamber but is also used for probe beam activities.

- To avoid freely propagating beam paths, the Chaco laser beam can be delivered via vacuum transport tubes to any of the 3 octagonal interaction chambers.

- Due excellent wavelength discrimination with respect to ZBL, very low probe beam energies can be used, prompting the installation of a duplicate of the Chaco multipulse front-end through the regen. This laser, called Gila, can be routed to the octagonal chambers as well.

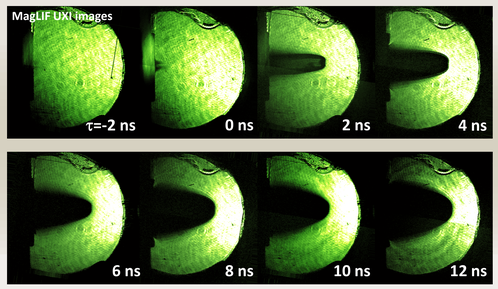
Chaco Layout:



Chaco Chamber Statistics

- Probe beam work intersects with the development of an ultrafast framing camera (UXI) capable of multiple acquisitions with interleaves of a few ns. This drives a multipulse capability on the Chaco laser via several methods (individually or in tandem):
  - Multiple pulsing the AWG within the 12.5ns roundtrip time of the regen,
  - Partial ejection of the regen pulse to establish a limited pulse train at 12.5ns spacing,
  - Optical split and delay after the regen for <10ns pulse separations, or
  - Multiple pulsing (within the gain lifetime of the Nd:YAG) of the regen Pockels cell to create pulses at as low as 50ns spacing.

- The probe beam/UXI camera development is facilitating MagLIF studies of the laser-driven evolution of thin plastics (1μm) over a laser entrance hole, with a 300 Torr backfill of Ne behind. One experiment captured eight 532nm Gila probe beam pulses (at 2ns spacing) on 2 interleaved UXI cameras for a *single ZBL shot* (2kJ/527nm).



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