Mykonos Pulsed Power Facility
Sandia National Laboratories
Pulsed Power Sciences Center

Working at the Mykonos Pulsed Power Facility

A User Guide for experimenters

September 13, 2024

Contents

Chapter 1

Introduction

1.1 The Mykonos Pulsed Power Facility

The Mykonos pulsed power driver is made up of five, three-meter-diameter linear transformer driver (LTD) cavities. Each cavity consists of 36 LTD bricks, each built with a 200 kV multi-gap switch and two 40 nF capacitors. The five cavities are triggered sequentially and drive a matched impedance coaxial water transmission line. The cavities are triggered with a 6.6 ns delay between cavities to match the transit time of the power pulse in the water transmission line. The cavities and water transmission line are shown in Fig. 1.1. The LTD cavities are designed to operate at up to ±100 kV charge voltage. At full charge voltage, Mykonos nominally produces a 1 MA, 500 kV pulse with a rise time (10%- 90%) of 80 ns and a pulse width (FWHM) of 160 ns into a 0.5 Ω matched load. Experiments are typically executed at a charge voltage of 85 kV, corresponding to about 850 kA peak current.

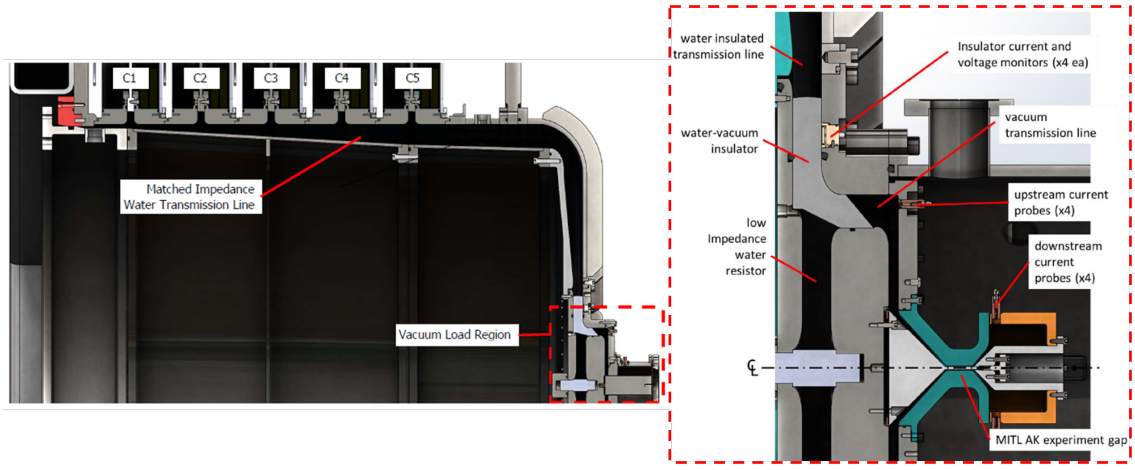

Figure 1.1. Cross-section view of the Mykonos LTD module (left) and the vacuum transmission line hardware (right).

1.2 Laboratory Layout

Mykonos occupies a large experimental highbay. Most of the space supports Mykonos operations, however, the lab is occasionally used to support Z Facility operations. Figure 1.2 shows the layout of Mykonos infrastructure. Most experimentalists will execute work within the Laser Control Area (LCA).

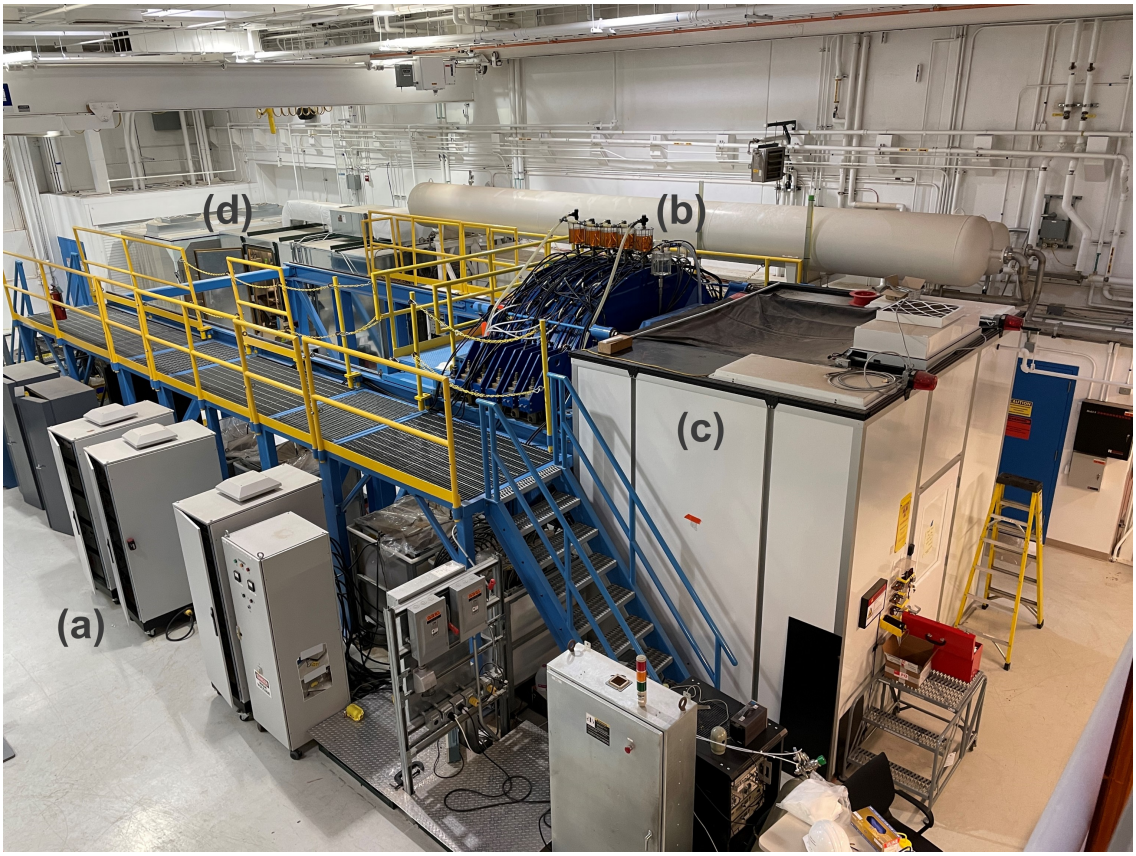

Figure 1.2. Bird's eye view of the Mykonos Facility. One can see the power supply racks for charging the capacitors in the front (a), with the five LTD cavities on the other side of the raised walkway (b). To the right is the laser controlled area (LCA) (c) that houses the target chamber (Fig. 1.3), lasers for diagnostics, optical breadboards, and various diagnostic instruments. The control room (d) is in the far back corner and blocked from view.

The 12 ft × 8 ft fully enclosed LCA houses the target chamber which is mounted to the HV vacuum insulator at a center-line height of 6 ft (Fig. 1.3). Campaign specific experimental powerflow and physics targets are installed inside the vacuum chamber. The chamber is surrounded by an 8 ft × 7 ft optical breadboard that allows for flexible diagnostic configurations. Two-level optical tables are located inside of the LCA, running along the left and right sides of Fig. 1.3.

The lower-level tables are 3 ft × 6 ft and support height-adjustable 2.5 ft × 5 ft upper-level tables. An additional 4 ft × 8 ft optical table is available just outside the LCA (just right of the view of Fig. 1.2) for target preparation and diagnostic staging. A workbench with a vice and

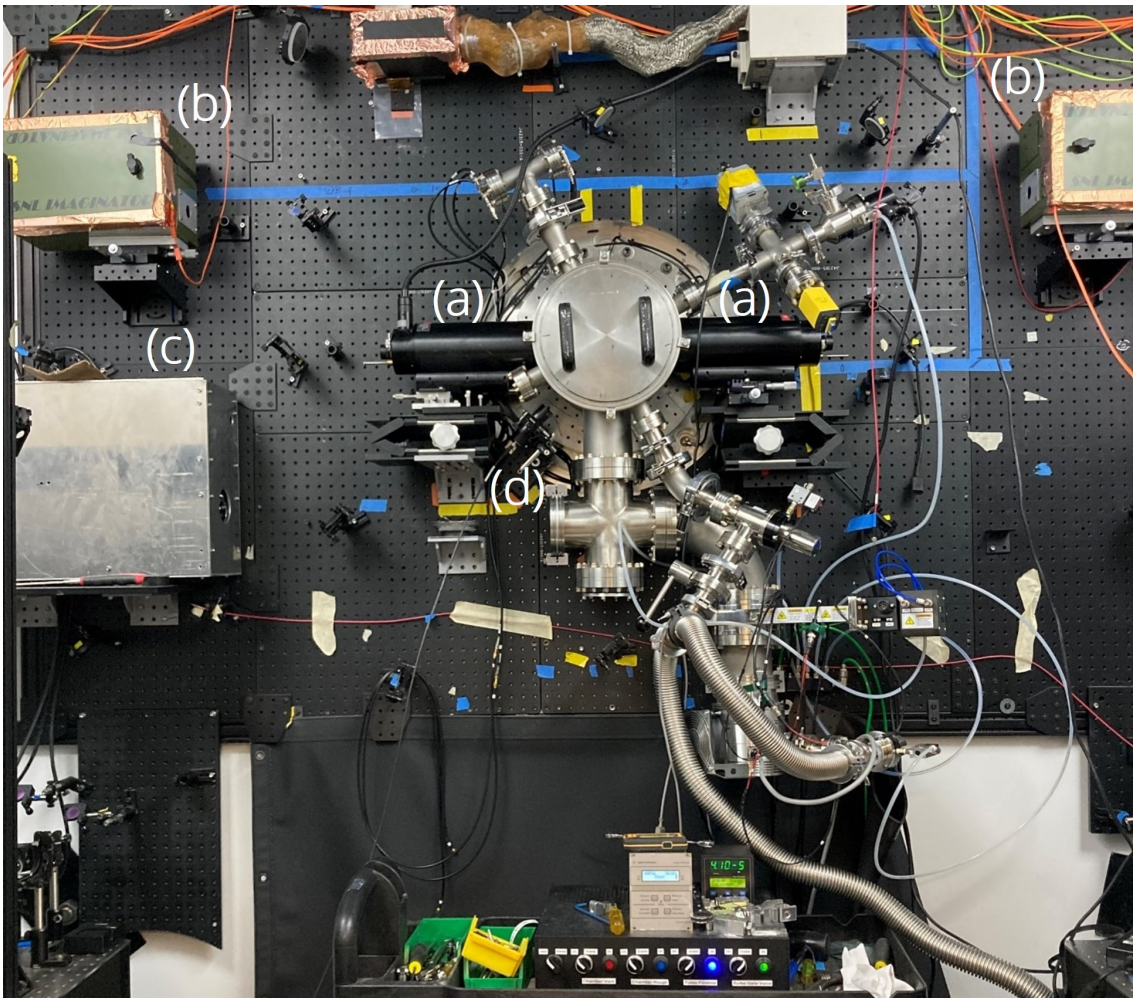

Figure 1.3. View of the Mykonos target chamber (center). Multiple lines of sight are available for various diagnostics. (a) Long-distance microscope, (b) single-frame ICCD, (c) 12-frame ICCD, (d) fiber-coupled Avalanche Photo Diode array (APD).

tooling (standard hand and power tools) is available for simple hardware repairs/modifications (just left of the view of Fig. 1.2).

While select diagnostics and equipment can be controlled and monitored from the LCA, data and control cables and fibers are generally run to the control room. The control room contains the computer which drives Mykonos facility operations and downline events. The control room also houses data acquisition hardware, including several fast digitizer channels. Experimenters may control instruments (e.g., scientific cameras) from the control room, typically using fiber optic-based communications. New cable and fiber runs can be installed temporarily or permanently upon coordination with Facility SMEs.

Chapter 2

Mykonos Campaign Timeline

After a proposal has been accepted for time on the Mykonos facility, we will require at least three separate reviews over the course of the campaign: Experiment Objectives Review, Shot Readiness Review, and Campaign Summary (see below).

- Meetings should be scheduled by the Principal Investigator according to the dates listed in the Mykonos Shot Calendar
- Attendees for these meetings should include, at a minimum: Your team members, the facility owner (Jens Schwarz), and the diagnostic scientist (Alex Sarracino).
- Meeting can be on Teams or in-person and should not exceed 30 minutes.
- Meeting slides should be stored here: \\snl\Collaborative\Mykonos\Experiment Campaigns

2.1 Experiment Objectives Review

In the first meeting, the Principal Investigator (PI) will share the experimental proposal with the facility. This typically occurs 12 weeks (or earlier) prior to the start of the campaign. In this meeting:

- Primary goals are defined and put in context with larger goals (e.g. program, milestone, academic degree).
- Relevant past work is summarized to address feasibility of achieving goals.
- Target/hardware design options are presented: Verify that experiment can be fielded on Mykonos.
- Simulations and/or theoretical analyses are shown (optional)
- List of essential diagnostics (see Appendix A) is prepared with linkage to experiment goals

- Any known long lead-time items are identified for targets, load hardware, diagnostics, etc.

2.2 Shot Readiness Review

During the second meeting, the PI will share the shot plan with the facility. This typically occurs 4 weeks (or earlier) prior to the start of the campaign. This meeting should cover the following topics:

- Shot plan with branching criteria
- Personnel needed and likely availability
- Diagnostics needed and expected support for fielding
- Status of targets
- Remaining Risks

2.3 Campaign Summary

At eight weeks post experiment, the PI shall share initial results and give feedback on facility performance.

- How did the campaign impact your future research direction?
  - How did this experiment advance your scientific goals?
- Did you uncover a need for new diagnostics or shot target change
- How did the facility perform and how might we improve?

Chapter 3

Experimental Operations

3.1 Experimental Preparation

Planning for Mykonos Facility experiments begins many months prior to the start of a campaign. Standard preparation like hardware design and procurement, diagnostic development, etc. will be handled by individual experimental teams. Interfacing with the facility is facilitated by early communication with the Mykonos Team.

Team members include:

Mykonos Facility Owner (access, training, etc.): Jens Schwarz

Mykonos Facility SMEs (pulsed power, Data Acquisition, experimental setup, etc.): Brian Hutsel, Derek Lamppa, Adam Steiner

Mykonos Laser SME (Laser imaging, diagnostic timing): Alex Sarracino

Mykonos Diagnostics SMEs: Alex Sarracino, Derek Lamppa (general), Nathan Hines (dispersion interferometer), Jacob Banasek (spectroscopy), Kevin Yates (PDV)

Mykonos Hardware/craning: Robert Obregon

Mykonos Machining support (hardware modifications): Larry Lucero

Mykonos Machine Operators: Brian Hutsel, Derek Lamppa, Adam Steiner, Karen De Zetter, Kevin Yates, Alex Sarracino, Trevor Smith, and Nathan Hines

3.1.1 Pre-job Briefing

A few days before the start of the campaign, the PI will get together with the Diagnostics SME (Alex Sarracino) and will conduct a pre-job briefing. The PI will lay out the main objectives and the required diagnostics, defining the next steps for the subsequent setup phase. During this meeting, the Diagnostic Space SME will review any safety concerns with the experiment team and review the expected conduct for working in the Mykonos facility (see

chapter 4 below). This includes a review (or introduction) to the treatment and handling of vacuum equipment, optics, hand tools, ladders, etc.

3.2 Experimental Campaign

Experiments on the Mykonos Facility are typically organized in multi-week campaigns. The Facility is reconfigured to meet the needs of each unique campaign. Changes are restricted to hardware within the LCA and control room. Experiments vary by vacuum vessel size/orientation, anode-cathode hardware geometry, diagnostic layout, and cabling/timing. The stages of a campaign may be organized as pre-job briefing, setup, shakedown, data collection, and tear-down. Different Facility Support Personnel play larger or smaller roles, depending on the stage of the experiment.

3.2.1 Setup

The first several days of an experimental campaign are often used for experimental setup. Mykonos does not fire during this stage. Crane lifts may be executed. New hardware may be brought into the lab and assembled/installed. Campaign specific cabling (data acquisition, triggering, etc.) will be configured. Do not remove any existing cabling unless you have contacted the respective SME prior.

3.2.2 Shakedown

Once campaign specific hardware/diagnostics are installed and configured, the experimenter may execute "shakedown" tests to develop confidence in the experimental setup. This may include trigger testing, using the Ekspla laser for diagnostic timing, firing Mykonos at low voltage to calibrate magnetic field probes, etc.

3.2.3 Data collection

After shakedown tests are complete, the experiment generally enters a phase of routine operations, where 1-4 experiments per day are executed. Mykonos operators fire the machine, while experimental teams prepare shot hardware and setup diagnostics for each shot. Typically, every 5-7 shots, a 1-2 hour pause is needed to remove select powerflow hardware within the vacuum vessel to enable cleaning/refurbishment of the insulator (to maintain reliable current delivery). The series of steps executed from one shot to the next are detailed in the "experimental day" subsection below.

3.2.4 Tear-down

At the end of the campaign, campaign specific hardware and diagnostics are removed, and the lab is cleaned and organized in preparation for the next experimental team. In general, a timely communication with the next PI is encouraged to facilitate a smooth transition to the next campaign. Here are some guidelines and general expectations for each area:

Laser Control Area

- If a vacuum chamber switch is required for the next experimenter, the chamber must be off at the end of your campaign.
  - At the start of a campaign, the next user is responsible for scheduling the mounting of the new chamber and pressure system population.
- All experimenter-unique diagnostics need to be removed from the vertical and horizontal optical boards.
- All modular "Mykonos facility" optics and optical components shall be taken down and stored appropriately.
- All experimenter-unique patch panel fiber and electrical signals shall be removed and stored.
- All Mykonos facility tools need to be put back into their respective toolsets.
- Please clean up trash, any scattered papers, and notes from your series. Any items remaining after one week may be discarded.

Target Preparation Area

- Clear and clean work surfaces for the next user. That includes:
  - Optical table and work bench
  - Workstation by the stairs
  - Multiple anthrocarts used for setting up diagnostic stations
- Discard of any shot hardware, diagnostic hardware, and debris shields that will not be refurbed
- Put away tools
- Put away modular optomechanics and optics in appropriate optics storage areas
- Remove from facility all user-specific equipment or store in approved storage in facility for user

Control Room

- Clear off Mykonos User Station and leave clear.
- If using Mykonos Control Station, clear off anything unique to your series
- Remove/store any diagnostic computers or devices
- Remove any custom fiber or electrical cabling from the room

3.3 Experimental Day

During the "data collection" phase of a campaign, experimental operations are generally quite routine. The typical steps from one shot to the next are detailed below:

- **Shot execution (downline event)**
- Review data from shot (with help from shot operator)
- Machine operator safes the facility (shuts down and locks out equipment)
- Experimentalists apply locks at group LOTO box (required prior to opening vacuum vessel)
- Experimentalists refurbish experimental hardware
  - Remove damaged/expended hardware
  - Clean re-usable hardware (low current electrodes, vacuum vessel, etc.)
  - Optional: Refurbish insulator/vacuum chamber
  - Install new/refurbished shot hardware, physics target, etc.
- Align/ready diagnostics
- Close vacuum vessel and pump down (LOTO locks can now be removed)
- Lock LCA
- Call shot operator to prepare the facility for the experiment
- Communicate changes in setup, diagnostic timing, etc. to shot operator (change header)
- Complete trigger tests and timing checks
- Ready for downline
- **Shot execution (downline event)**

Chapter 4

Expectations for working and performing experiments at the Mykonos Facility

4.1 Hardware Handling

A large selection of clean, undamaged optics is essential for the success of much diagnostics at the Mykonos facility. As such, we require that gloves are worn when handling or aligning optics. If you encounter damaged or dirty optics, please set them aside and contact the diagnostic SME when convenient.
Similarly, please cap off fibers when not in use. This will increase their longevety, reduce cleaning times, fiber maintenance, and will increase your signal to noise ratio.
Vacuum base pressure and pump down times are critical for every experiment. Please take great care when modifying the vacuum system: wear gloves to avoid contamination and keep the surfaces clean and wrapped in aluminum foil when not in use. If you discover leaking hardware or scratches around knife edges, please contact the vacuum SME for guidance.

4.2 Shot Readiness and Execution

Shot time at the Mykonos facility is a precious commodity. With the increased demand for shot time, individual campaigns may have to be shortened to accommodate a larger number and variety of experiments. As such, it is expected that Principal Investigators (PIs) and their teams are ready to start at day one. Part of this preparation is the completion of the "Experiment Objectives Review" and the "Shot Readiness Review". PIs are strongly encouraged to develop a shot plan for each upcoming week that contains expected shot and refurbishment time windows so that shot operators and maintenance personnel can be scheduled accordingly. It is not acceptable to be unprepared. If unforeseen issues should arise, please contact the Mykonos Facility owner immediately and one may be able to re-schedule

the campaign at a later date.
Under healthy machine operating conditions, it is expected that no shot day is left unused and that at least part of the experimental team are present to perform work; that includes Fridays. If no shot operator can be found for Fridays, then this time is dedicated to facility clean-up and improvement. If it becomes evident that machine time cannot be utilized effectively or is not valued, then this could affect future shot allocation time in favor of better prepared PIs.

Chapter 5

Training Requirements

The Mykonos Facility has well defined training requirements that are tracked through the Z Qualification and Access (ZQAT) web-tool. Mykonos users will have varying training requirements based on the work they will execute. Training is assured by completing the respective "Activity" in ZQAT. As an example, all users will have to complete the "Phase B Access" activity in order to gain access to the Mykonos facility (i.e. Phase B). Appropriate training will be assigned by the facility owner (Jens Schwarz) and can be completed and tracked in ZQAT.

Job Role	Activity Name	Requirement Name
Mykonos - Load Installer	MYK - Load Installer	CHM100 CHM103 LTO210/LTO210I MykonosRadTWD.E
	Phase B Access	BEA100/BEA100A CHM100 CHM103 CTR_NGDOSE_POL_Rev.A SC042 - 983 (Phase B) Mykonos and Vacuum Chamber

Figure 5.1. Example of training matrix for "Mykonos – Load Installer

Figure 5.1 shows an example of a typical training matrix. In this case: "Mykonos - Load Installer". This is a training you will need if you want to work on the Mykonos Target chamber, e.g. Install your targets, align diagnostics, etc. Each "Job Role" consists of a number of activities, in this case: "Phase B Access", and "MYK – Load Installer". Each activity has training requirements that are listed in the last column. Most of the trainings can be taken on-line, while some are site-specific and in-person. We suggest that you arrive one week prior to that start of your campaign so you can get settled and take the necessary trainings.

Check	Item	Notes
☐	Obtain your Mykonos access card by e-mailing the Mykonos facility owner: jschwar@sandia.gov	Your card will not work on the door after 6 pm to get back into the building! (You will need to request special access if you want to enter before 6 am, after 6 pm or on weekends)
☐	Report to work and connect with your team	• Meet with Mykonos facility owner: Jens Schwarz • Meet with Derek Lamppa and Alex Sarracino to discuss experimental area • Meet with Brian Hutsel to discuss what signals are needed/input for DAS • Meet with Robert Obregon to discuss what hardware requirements are necessary • Meet with Larry Lucero to discuss any machining capabilities you will require during shots.
☐	Tour of Mykonos & important knowledge share	• Basic tour (where to get food, water, bathrooms, print things, etc.) • Mykonos walk-through (Screen room & DAQ, optic bench staging area, LCA, hand tools, optical supplies) • Discussion of Z evacuations • If you have specialty parts, consider bringing your own tools • Timing diagram to calculate all delays, especially if you are changing time of flight pathlengths or are using new/additional cables • Order extras of ALL your hardware that could be damaged during a shot (especially anode / cathode!) • Access to optics cabinet/fibers • If pressure safety trained, steps to pump down chamber • Which chamber are you using? (ETI, Derek, etc). Check for enough debris shields, spare windows, new gaskets
☐	Complete necessary safety paperwork & get lock for LOTO	• LOTO 210 (or "Limited Authorized Worker Form") • Sandia required training in TEDS • ZQL assignments for Mykonos specific

Table 5.1. Mykonos on-boarding checklist.

Appendix A

List of currently available Diagnostics

The list below includes diagnostics that have been fielded at the Mykonos Facility. Most of them will be available at any given time, except for those that are shared with the Z Facility. Experimenters will need to work closely with their Sandia counterpart when requesting or bringing in diagnostics.

Optical Diagnostics:

- Four-frame pulsed laser imaging system (170 ps pulsed laser, 5-ns inter-pulse delay) at 1064 nm, 532 nm, 355 nm, and 266 nm.
  - Interferometry
  - Shadowgraphy
  - Schlieren
  - Angular Filter Refractometry
- Avalanche photodiode (APD) and other diode detectors (time-resolved self-emission, filterable)
- Three single-frame Andor iStar ICCDs; Minimum Exposure Time: 2-3 ns (2 ea. Model 334, 1 ea. Model 340)
- Four-frame ICCD camera
  - Specialized Imaging Model SIMX4
  - Exposure Time: 3 ns - 10 ms in 1 ns steps
  - Inter-frame Time: 0 ns - 20 ms in 1 ns steps

- Eight-frame ICCD
  - Cordin Model 222
  - Exposure Time: 2.5 ns - 10 ms
  - Inter-frame Time: 0 ns - 10 ms in 250 ps steps
- Twelve-frame Ultra High Speed Framing Camera (requires coordination with the ECE department of the University of New Mexico)
  - Invisible Vision UHSi 12/24
  - Exposure Time: 5 ns - 1 ms in 5 ns steps
  - Inter-frame Time: 0 ns - 10 ms in 5 ns steps
- Questar QM100 Long-Distance Microscope assemblies for imaging of $\approx 1\mu$m phenomena
- Photonic Doppler Velocimetry
- Streaked Visible Spectroscopy (SVS)
- Two-color dispersion interferometer
- Gated visible spectroscopy (1D spatial distribution)
- Gated Vacuum Ultraviolet (VUV) Spectroscopy (1D spatial distribution)

X-ray Diagnostics:

- Filtered PIN diodes
- Support for image plate
- Ultra-fast x-ray imager (UXI), (in commissioning phase)

Electrical Diagnostics:

- Standard machine diagnostics (machine current and voltage into vacuum chamber)
- Standard load B-dots (current into load region)
- Inductive voltage monitor (voltage into load region)
- Micro-B-dots (small field sensors for localized current measurements)

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