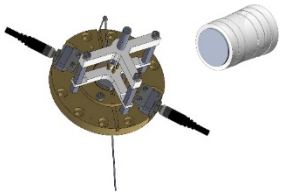
DCS | Dynamic Compression Sector

Appendix - Experimental Facilities

Impact Facilities

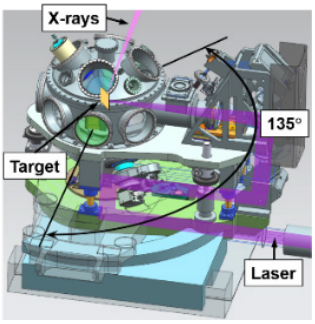
- Single-Stage Gas Gun (SSGG), Powder Gun (PG), and Two-Stage Light Gas Gun (2SLGG), each with a ½" bore; impact velocities to ~ 6 km/s
- Impact launchers mounted on remotely controlled motion control systems with linear and angular resolutions of 10 μm and 1 mrad (0.06 degrees), respectively
- Remotely controlled rotatable target holder (± 2.5μm with < 0.5 μm resolution)
- Optical Beam Breaks (OBBs) in the barrel, impact chamber, and target allow synchronization of x-ray pulses and recording instrumentation
- Standard Impactors (Al, Cu, Ta, LiF, polycarbonate) provided to users
- On average, users can expect to complete 4 – 6 experiments per day (after experimental setup is complete)



Example Target and 2-Stage Gun Projectile

Laser-Shock Facilities

- 100J laser system with a 351 nm wavelength on target
- 5-15 ns pulse duration with smooth focal profile for uniform ramp and shock compression (500 μm spot size)
- Flexible pulse shape control and high throughput (one shot every 25 minutes)
- Highly flexible target chamber with translation stage and 135° rotation to vary angle between x-ray and
- laser beams
- Multiple ports for simultaneous diagnostics
- Excellent synchronization (200 ps) between laser pulse and single x-ray pulse (isolated with high speed chopper) to obtain real-time, x-ray data
- Target holder for up to 24 targets



Target Chamber

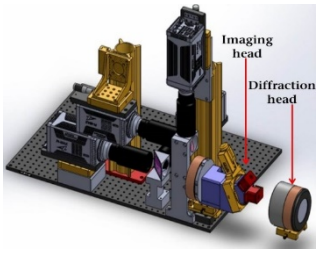
X-Ray Detectors

Four-frame detector system allows "movies" of dynamic compression using 100ps x-ray pulses

- Fast scintillators convert x-rays to visible photons at an image plane (40mm diameter)
- Three large beam splitters direct light to four, lens-coupled intensified CCD (ICCD) cameras
- ICCD triggers are synchronized to the APS x-ray pulses and can be triggered to match the x-ray bunch spacing in 24-bunch mode (see Table 1 – X-ray Beam Modes)
- Modular system allows replacement of front-end for multiple diagnostics techniques: X-ray diffraction (XRD); Phase contrast imaging (PCI); Small-angle x-ray scattering (SAXS); Radiography

Front-End Options

- X-ray phosphor (LSO:Ce) coupled to fiber taper (75 or 150mm) and image intensifier (P47 phosphor)
  - 75mm taper has high sensitivity for XRD of high Z materials, SAXS measurements, and radiography
  - 150mm taper has lower sensitivity, but higher angular coverage to obtain additional XRD data for lower Z materials
  - Typical target to detector distance for XRD: 150mm (varies with experimental setup)
- LYSO:Ce single crystals coupled to microscope objective for PCI measurements
  - Available fields-of-view: (0.6 mm x 0.6 mm) – (1mm x 1.5mm)
  - Highly variable target to detector distance to maximize contrast



Four-frame detector system

Optical Diagnostics for Time-Resolved Continuum Measurements

PDV

- 12 channels with upshifting capability
- 5 W IPG laser with RIO seed laser

Dedicated Optical Diagnostic Digitizers

- 8 digitizer channels (8 GHz and 12.5 GHz) for PDV
- 8 digitizer channels (1 GHz) for VISAR

VISAR

- 8 fixed VPF Push-Pull VISARs
- Return light splitting for dual VPF measurements
- Available VPFs (m/s/fringe): 72, 95, 181, 308, 458, 738, 945, 1555
- 6 W VERDI laser source

X-Ray Beam Modes and Properties

The Insertion Device (ID) for the DCS is a Revolver Undulator that can be switched between two periods – 27 mm and either 30 mm (available now) or 17.2 mm (available in 2017) to provide continuous spectral tuning in energy from 5 to 100 keV.

The beamline optics are designed to deliver four x-ray beam modes that can be fine-tuned in energy, beam-size, bandwidth, and flux to deliver the appropriately conditioned beam for a particular experiment. For example, broad-band white beam is particularly useful for high-energy Phase Contrast Imaging (PCI) while narrow-bandwidth monochromatic beam (~0.01% Bandwidth (BW)) may be used for precision diffraction measurements. Focused pink beam (1-5 % BW) is most useful for obtaining a series of high-flux, single-pulse snapshots where only a single ~100 ps x-ray burst is recorded per frame on an area detector.

Table 1: X-Ray Beam Modes

Bunch Mode	X-Ray Spacing	Current Bunch (102mA Total)	Weeks per Run
24	153.4ns	4.25mA	6 - 8
324	11ns	0.31mA	2 – 3
Hybrid	1.6μs, 11ns	16mA, 1.5mA	2

Table 2: Available X-Ray Beam Spot Sizes

Beam Types and Energy Ranges	Enclosure	Spot Size
Maximum White Beam Spot Sizes Energy Range: 5-100 keV	Special Purpose (B-Station)	1.4(V) x 2.1(H) mm^2
	Laser-Shock (C-Station)	1.8(V) x 2.7(H) mm^2
	Impact Facility (D-Station)	2.2(V) x 3.3(H) mm^2
	Impact Facility (E-Station)	2.5(V) x 3.7(H) mm^2
Minimum Pink and Monochromatic Beam Spot Sizes Energy Ranges: 5-35 keV Pink Beam 5-35 keV Monochromatic Focused 5-54 keV Monochromatic Un-focused	Special Purpose (B-Station)	25(V) x 150(H) μm^2
	Laser-Shock (C-Station)	36(V) x 36(H) μm^2
	Impact Facility (D-Station)	70(V) x 120(H) μm^2
	Impact Facility (E-Station)	26(V) x 106(H) μm^2

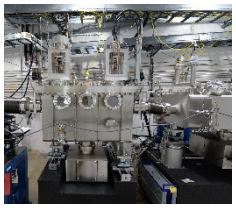
Table 3: Experimental Capability with APS Beam Modes

Experiment Type	Compatible Bunch Mode
Plate Impact	24
Laser Drive	Hybrid and 24
Special Purpose	Experiment Dependent
Ambient Conditions	Any, but 324 preferred

X-Ray Characterization

Complete set of x-ray diagnostics in each station for precise alignment, focus, and characterization of x-rays for each experimental setup

- Laser aligned to x-rays provides visible beam path for initial alignment
- GigE camera coupled to YAG crystal with microscope objective for precisely focusing and shaping x-ray beam
- Spectral flux characterization using Si(220) monochromator on precision rotation stage



Horizontal Focusing Mirror

Sample Preparation and Characterization

Sample Preparation Equipment

- Thermal evaporation deposition machine
- Variable speed diamond and abrasive precision saw
- Lapping and polishing machines
- Heated presses
- Machine shop with lathe, mill, and vertical band saw
- Sample presses, soldering station, and variety of hand tools

Metrology Equipment

- Ultrasonic longitudinal and shear sound speed measurement system
- High precision sample measurement capability (dimensions, flatness and parallelism)
- High precision density measurement station with precision scale (0.0001 g resolution)
- Stereo microscope
- Upright metallurgical microscope with built-in encoders