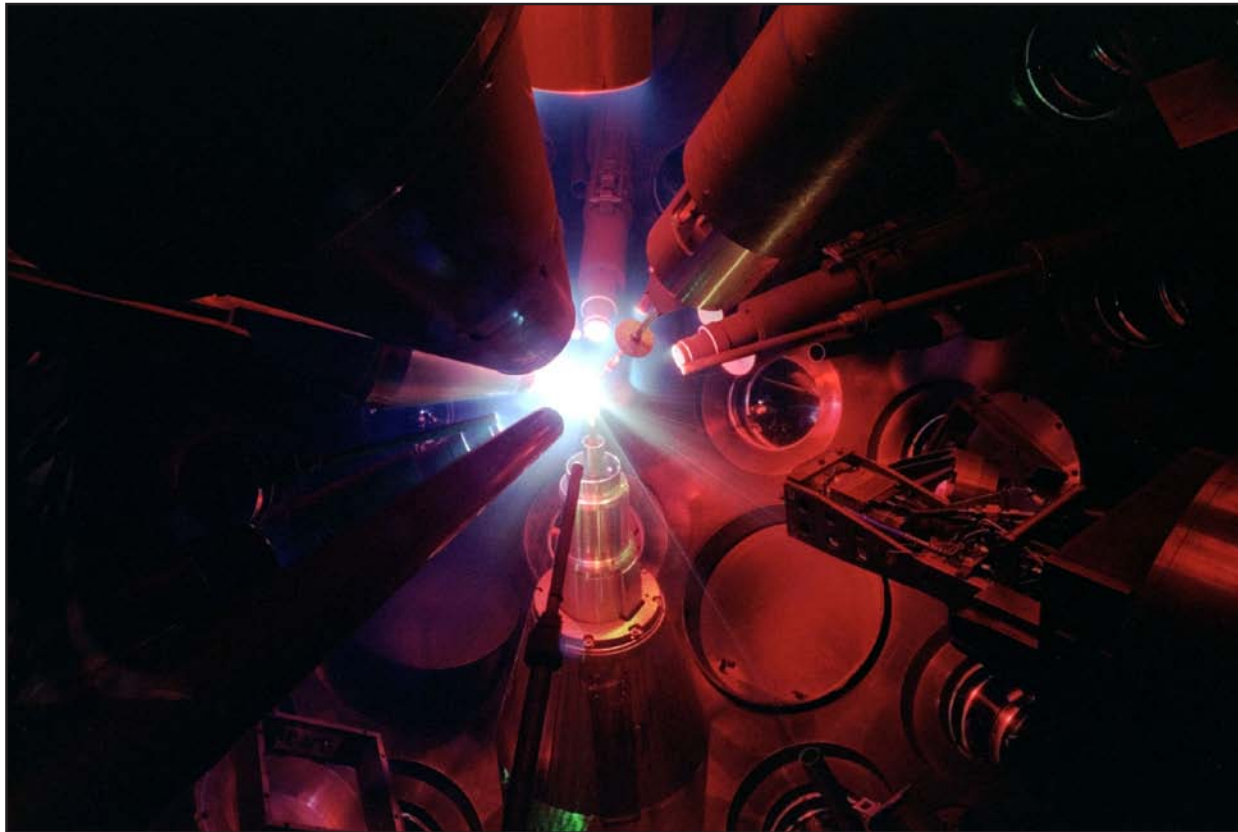


OMEGA Experimental Operations

2011 OLUG Status Report



Greg Pien
University of Rochester
Laboratory for Laser Energetics

Omega Laser Facility
Users' Group Workshop
Rochester, NY
27–29 April 2011

LLE is responding to the 2010 OLUG findings



- Diagnostic information availability has been improved
- New diagnostics are available
- Expect continued enhancements in the future

OLUGS
Diagnostic User's Guide

XRS Spectrometer

Summary: The XRS spectrometer is a TM mounted, time integrated, single channel Rowland Circle X-Ray spectrometer that supports the use of a variety of crystals to record X-Ray spectra ranging from 600 eV to 25 KeV.

Instrument Specialist: Sarah Yasuda (ysuda@le.rochester.edu)

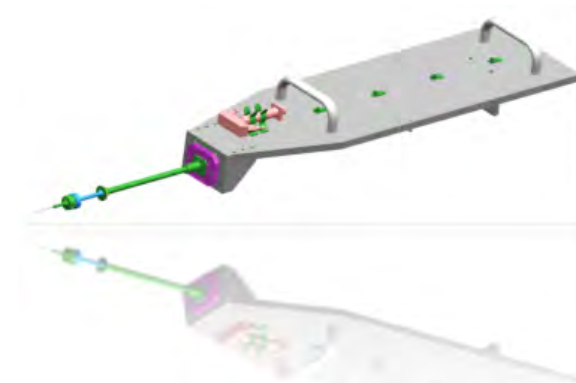
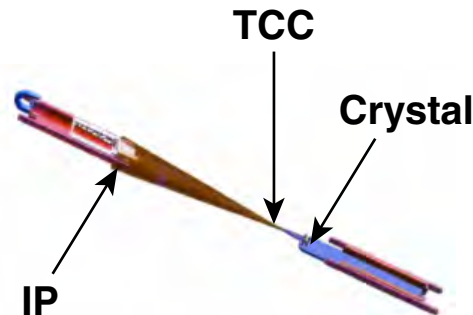
Specification	Q	QEP	Notes
Locations	TMU 1.1.A.1.1	TMU 1.1.1.1.1	Not allowed on opposite IP beams
Recording media	File (Bufile, QEP) or Image Plate	File (Bufile, QEP) or Image Plate	Only Bufile or Image Plate is supported by LLE
Filters	As listed under this page	As listed under this page	Be authorized. Typical 0.005" Be as filter peak
Sites	25mm - Same as prior	25mm - Same as prior	Right tight section. Positive entry slot possible

Available Energy (KeV) Ranges (one per XRS)

K1 is minimum and K2 maximum of range

Crystal	K1	K2	K1	K2	K1	K2	K1	K2
Si	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015
Ge	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015
Al	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015
Fe	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015
Co	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015
Ni	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015
Cu	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015
Zn	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015
Ag	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015
Au	0.010	0.015	0.010	0.015	0.010	0.015	0.010	0.015

Page 13 of 13



Takeaways from OLUG 2010



User oriented documentation for target diagnostics

- **Users' guides for diagnostics**
 - photos for reference
 - performance space
 - options and features
- **Access to diagnostic qualification packages**
- **Up to date Target Chamber port assignment lists**
- **Access to Ph.D. theses**

Takeaways from OLUG 2010 (continued)



Enhanced diagnostics suite

- Spherical crystal imagers
- Electron spectrometers
 - additional units of current LLNL design
- OMEGA EP 4ω probe beam
- OMEGA EP planar cryogenic target capability
- OMEGA EP gas jet target capability
- 20-MeV gamma spectrometer

Improvements to OMEGA/OMEGA EP online information



Online Users' Guides

Go To RID# This RID#: 34514
 Last Modified: 19-Apr-2011 14:08:29
[Facility Status](#)
[Comments/Problems](#)
[XOPS](#) [Beamlines](#)
[Help](#)

[General](#) > [Drivers](#) > [Target](#) > [Beams](#) > [TIM](#) > [Fixed](#) > [Neutronics](#)

Rowland(Yaakobi) XR Spectrometer 2 (XRS) / TIM 1 [Operating Procedures](#) [Users Guide](#)

Internal Settings

Crystal Type:

Crystal Surface:

Crystal Length: cm

Crystal Width: cm

Crystal Position:

Crystal Tilt:

Blast Shield Thickness (Be):

Filter Material:

Filter Thickness:

Slit Width: um

Pinhole Diameter:

External Settings

Shift to Target:

Energy Range: to eV

Steering

Make selections in one row only

☒ Target Chamber Center

☐ Radius um Theta Phi

☐ Distance um toward Port

Misc.

Detector Type:

Film-cassette Be thickness:

[Campaign Editor](#) [Drivers Editor](#) [Beam Editor](#) [SRF Auditor](#)

ΩXOPS Diagnostic User's Guide

XRS Spectrometer

Summary: The XRS spectrometer is a TIM mounted, time integrated, single channel Rowland Circle X-Ray spectrometer that supports the use of a variety of crystals to record X-Ray spectra ranging from 600 eV to 23 KeV.



Instrument Specialist: Barukh Yaakobi (byaa@lle.rochester.edu)

Specification	Ω	ΩEP	Notes
Locations	TIMs 1,3,4,5,6	TIMs 12,13,14	Not allowed on opposite SP beams
Recording media	Film (BioMax, DEF) or Image Plate	Film (BioMax, DEF) or Image Plate	Only BioMax or Image Plate is supplied by LLE
Filters	At blast shield and film pack	At blast shield and film pack	Be authorized. Typical 0.001" Be as film pack light tight window
Slits	25μm – 5mm typical	25μm – 5mm typical	Pinhole array also possible

Available Energy (KeV) Ranges (one per XRS)

E1 is minimum and E2 maximum of range

Crystal position	2D (Å)	1	2	3	4
		E1	E2	E1	E2
Si	3.8400	11.714	23.200	7.3854	14.353
LaF	4.0270	11.170	22.122	7.0234	13.687
Ge	6.5450	6.8726	13.611	4.3213	8.4212
PET	6.7420	5.1454	10.191	3.2353	6.3048
ADP	10.640	4.2276	6.3759	2.6582	5.1801
KAP	26.380	1.6923	3.3517	1.0641	2.0756

Improvements to OMEGA/OMEGA EP online information (continued)



Online access to operating procedures

OMEGA EP
Shot Request Form

UR LLE

Go To RID#
This RID#: 34682
Last Modified: 08
-Feb-2011 11:23:09

Facility Status
Comments/Problems
Help

General > Select
Beam/Source > Set up
Beam/Source > Target >
TIM > Fixed >
Neutronics

Proton Film Pack II 12 (PFP) / TIM 12 Operating Procedures

Setup

Film Pack Configuration	Dual pack - Near Normal	
	Film Pack 1 (Normal)	Film Pack 2 (Orthogonal)
Film Pack Assembly	60MeV	60MeV
Distance to Target	80 mm	

Comments/Requirements

Steering

Make selections in one row only

☒	Target Chamber Center		
☐	Radius um	Theta	Phi
☐	Distance um toward Port		

Vol. VIII System Shot Operations:
Chapter 6 Experimental Diagnostics:
D-TX-P-007 Rev F

April 19, 2010

6-2.1 PROTON FILM PACK (PFP)

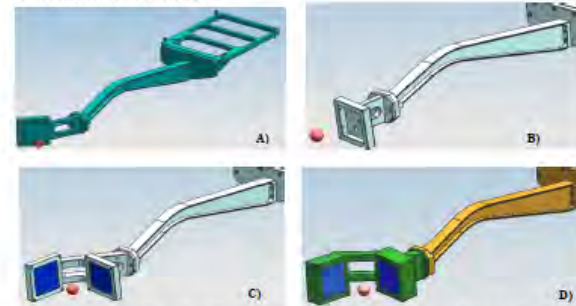


Figure 1: A) Single at 45°; B) Single Normal; C) Dual and D) "Adjustable" Dual Film Pack Assemblies

Diagnostic Description

Developed by Lawrence Livermore National Laboratories (LLNL), the Proton film Pack (PFP) contains stacks of radiochromic film separated by aluminum foils (i.e. PFP 60MeV). The Proton Activation Pack (PAP) contains copper foils, aluminum foils and radiochromic film. Each "Pack" records the energy spectrum and beam profile of a proton beam. The diagnostic is a TIM based instrument which requires no power, timing or communications. Four (4) film pack arm set-ups have been adopted with the reconfigured design as shown in Figure 1.

Diagnostic Warnings

1. The payload extends beyond the standard Diagnostic Space Envelope (DSE). Hence, special considerations are required for its use to avoid collisions with other TC diagnostics. This also includes interference with the TVS viewing window when deployed at TCC.
2. On shots with Energy on Target (EOT) greater than 400J, the film pack must be subjected to a radiological survey upon opening the TIM because activation may reach levels that require precautions.
 - o Use of the portable Ludlum Model 9 Ion Chamber in conformance with the "LLE Radiological Controls Manual 6610, Section 3015 - Material with Fixed Activity" is required.
 - o Take appropriate measures should activity level be ≥ 5 mR/h (Radiation area).

University of Rochester
Laboratory for Laser Energetics

2 of 11

Improvements to OMEGA/OMEGA EP online information (continued)



Online target chamber port assignment lists

OMEGA EP - Target Chamber Port Assignments
11/22/10

EP Operations Page

Facility	Shot Related	Operations
- Weekly Schedule (Schedule Editor (restricted)) - Quarterly Schedule - Facility Watchbill - Facility Status: 12/28/2010 - Diagnostic Status: - Editor (Restricted) - Effectiveness Report TC Port (Excel) 11/22/2010 - Training Schedule 12/28/2010 - LLE Phonebook - Paging System	- Proposal Template - Report - Approval (Restricted) - Shot Request Form - Report (Station) - Auditor - Unlock (Restricted) - Configuration - Shot Images and Reports - Target Request Form - Film Digitization Request - Pulse Shape - Request New - In Fabrication - Experimental Effectiveness Assessment - Editor (restricted) - Detailed Effectiveness Rating - Far Field and Wavefront - Upload Images (Restricted)	- XOPS - Opto-Mech - Sources - E-log: - Amplifiers - Beamlines - Laser Sources - Power Conditioning - Shot Director - XOPS - Omega EP Hardware Timing - Laboratory Hardware Timing - EP Program Log

Port ID	Assignment	Port Diameter (inches)	Radius (inches)	Theta (degrees)	Phi (degrees)	Opposite Port	Comments
1	CTHS CRYO UPPER	18	64.02	0	0	80	
2	TIM # 10	18	64.02	27	0	87	D-TA-C-40
3	Unassigned	18	64.02	27	45	88	
4	Unassigned	18	64.02	27	90	X	
5	Unassigned	18	64.02	27	135	89	
6	Unassigned	18	64.02	27	225	85	
7	TPS-7	18	64.02	27	270	x	D-TA-C-13
8	Unassigned	18	64.02	27	315	86	
9	PORT CENTER	36	61.80	41	180	82	B-DM-C-469
9A	TIM # 11	18	66.00	39	189		
9B	TC vacuum gauge #1	NW40	65.05			NA	Does not point to TCC
9C	TC vacuum gauge #2						Does not point to TCC
9D	Unassigned						Does not point to TCC
9E	Unassigned						Does not point to TCC
9F	RGA						Does not point to TCC
9G	Unassigned						Does not point to TCC
9H	Unassigned						Does not point to TCC
10	Unassigned	12	64.45	43	11.25	81	
11	Unassigned	12	64.45	43	33.75	X	10" Maximum Envelope beyond flg.
12	Unassigned	12	64.45	43	56.25	X	
13	Unassigned	12	64.45	43	78.75	X	Not Available - Upper deck interference
14	Unassigned	12	64.45	43	101.25	X	Not Available - Upper deck interference
15	Unassigned	12	64.45	43	123.75	X	
16	Unassigned	12	64.45	43	236.25	X	
17	Unassigned	12	64.45	43	258.75	X	Not Available - Upper deck interference
18	Unassigned	12	64.45	43	281.25	X	Not Available - Upper deck interference
19	Unassigned	12	64.45	43	303.75	X	
20	Unassigned	12	64.45	43	326.25	X	10" Maximum Envelope beyond flg.
21	Unassigned	12	64.45	43	348.75	80	
22	THVL - Laser Plate Absorption	12	64.45	58	142	79	
23	TC Viewport 1	12	64.45	58	218	x	
24	TC Viewport 2	12	64.45	58	322	77	
25	PORT CENTER	18	64.02	60	0	73	
25 A	HFES						
25 B	BMXS		65.05			NA	
25 C	BMXS						
26	Unassigned	18	64.02	60	60	74	
27	X TVS Illuminator	18	64.02	60	90	76	D-TA-C-082
28	Unassigned	18	64.02	60	120	76	
29	Unassigned	18	64.02	60	240	X	
30	Unassigned	18	64.02	60	270	71	
31	TIM # 15	18	64.02	60	300	72	
32	Y TVS Illuminator	12	64.45	69	180	68	D-TA-C-083
33	BACKLIGHTER ENTRY	26	63.20	70	37.5	x	

Improvements to OMEGA/OMEGA EP online information (continued)



Online access to experiment configuration relevant Ph.D. theses

Laboratory for Laser Energetics
a unique national resource

Home ▾ About ▾ Omega Laser Facility ▾ Engineering Services ▾ Safety Zone ▾ **Publications ▾** Resources ▾ Site Map Phonebook

Welcome to LLE

The Laboratory for Laser Energetics (LLE) of the University of Rochester is a unique national resource for research and education in science and technology. LLE was established in 1970 as a center for the investigation of the interaction of intense radiation with matter. The National Nuclear Security Administration funds LLE as part of its Stockpile Stewardship Program.

Quick Shot

Magnetized ICF Targets

Various coil designs have been utilized in experiments with magnetized ICF targets using the magnetic field generator MIFEDS. Shown are four different coil shapes, ranging in size from 6 to 16 mm, superimposed on an image of a target shot (OMEGA S/N 59300) which utilized one of these coils. Inside the target chamber, the shot image measures about 0.9 m across. Additional information on the system may be found in this [Around the Lab](#) article. [Past Quick Shots](#)

Around the Lab

Multilayer Dielectric Gratings for OMEGA EP

High-energy, petawatt (HEPW)-class lasers

Publications ▾

- LLE Review
- Annual Report
- DOE Report
- Presentations
- Viewgraphs
- Calendars
- Theses**
- High School Reports

Quick Links

- LUF
- Laboratory Basic Science Solicitation Complete
- Omega Laser Facility Users Group
- Laser Group
- 2010 Conference

OMEGA Operations
Schedules, reports, and documentation. Password required

Omega Laser Facility Schedule
Listing of available schedules for the Omega Laser Facility

Career Opportunities
LLE employment opportunities and contact information

DOE Monthly Report
Synopsis of current laboratory activities, including a summary of OMEGA operations

Educational Opportunities
Information about undergraduate and graduate research

Meetings
Websites for meetings and conferences hosted by LLE

Viewgraph Database
Restricted to LLE users

Laboratory for Laser Energetics
a unique national resource

Home ▾ About ▾ Omega Laser Facility ▾ Engineering Services ▾ Safety Zone ▾ **Publications ▾** Resources ▾ Site Map Phonebook

Search Theses

LLE Theses

Author	Title	File Size	Year
A. S. Cross	Ultrafast Time-Resolved Characterization of (Cd,Mn)Te Semiconductors as Radiation Detectors	3.0 MB	2011
M. Barrios Garcia	Precision Equation of State Measurements on Hydrocarbons in the High Energy Density Regime	4.5 MB	2010
L. Sun	All-fiber Faraday Devices Based on Terbium-doped Fiber	2.8 MB	2010
M. Storm	Fast-Electron Source Characterization and Transport in High-Intensity Laser-Solid Interactions and the Role of Resistive Magnetic Fields	3.8 MB	2009
J.-H. Yang	An Empirical Model for the Interaction of Ultraintense Laser Pulses with Fully Ionized Plasmas Including Electrostatic Effects	8.4 MB	2009
M. C. Ghile	Neutron Imaging with Bubble Chambers for Inertial Confinement Fusion	5.9 MB	2009
H. Sawada	Experimental Investigation of a Direct-Drive Shock Wave Heated and Compressed Planar Target Relevant to ICF	8 MB	2008
C. D. Zhou	Fuel Assembly for Conventional, Fast and Shock-Ignition Direct-Drive Inertial Confinement Fusion	1.8 MB	2008
J. E. DeGroot	Surface Interactions Between Nanodiamonds and Glass in Magnetorheological Finishing (MRF)	5.9 MB	2007
J. E. Miller	High-Pressure Equation-of-State of Porous-Ta₂O₅	1.7 MB	2007
A. K. Knight	Analysis of the Discrete Stages of the Formation of Polyimide Films by Vapor Deposition and Their Effects on the Films Properties	2.6 MB	2007
S. N. Shafir	Surface Finish and Subsurface Damage in Polycrystalline Optical Materials	34.5 MB	2007
S. Sublett	OMEGA Laser-Driven Hydrodynamic Plasma Jet Experiments with Relevance to Astrophysics	78.7 MB	2007
A. Trajkovska Petkoska	Enhanced Electro-Optic Behavior of Polymer Cholesteric Liquid Crystal Flakes in Host Fluids	15 MB	2007
S. Wu	Time-Resolved Characterization of Carrier and Phonon Dynamics in GaN Single Crystals	4.7 MB	2007
K. S. Anderson	Adiabatic Shaping in Direct-Drive Inertial Confinement Fusion Implosions	1.7 MB	2006
A. C.-A. Chen	Full-Color and White-Light Polarized Light-Emitting Diodes Using Monodisperse Conjugated Oligomers	10.8 MB	2006
S. W. Culligan	Organic Blue Light-Emitting Diodes and Field-Effect Transistors Based on Monodisperse Conjugated Oligomers	1.9 MB	2006
M. Haurylau	Tunable 2-D Photonic Bandgap Structures for Optical Interconnects	12.3 MB	2006
O. V. Gotchev	Experiments on Dynamic Overpressure Stabilization of the Ablative Richtmyer-Meshkov Instability in ICF Targets	2.1 MB	2006

28 diagnostics have qualified since OUG 2010



OMEGA

- LLNL Electron-positron proton spectrometer (EPPS)
- LLNL hardened gated x-ray imager (hGXI)
- LLE NIF 4.5 neutron bang time detector (NBt4.5-O)
- LLE 5.3 m CVD neutron detector platform (H10CVD)
- LANL gamma reaction history diagnostic phase V (GRH)
- LANL NIS pinhole manipulator upgrade (NIS-PHM-O)
- CEA NIS pinhole manipulator upgrade (NIS-PHM-O)
- LLE MCTC7 cryostat upgrade
- LLNL rSPCA pinhole camera
- LANL Thompson parabola ion energy analyzer (TPIE)
- CEA XCCS crystal spectrometer
- LLE hard x-ray diode spectrometer upgrade (HXRD)
- LLNL zinc von hamos spectrometer II
- SNL PCD array
- LLE wedge range filter upgrade
- LLE neutron diagnostic inserter (NDI)
- LLE MCTC dock 5
- LLE CVD TIM platform (CVDTIM)
- LLE D₂ NTOF
- LANL gas cerenkov detector 2 (GCD2)
- LLE/LANL PXRDIP compatible ASBO upgrade

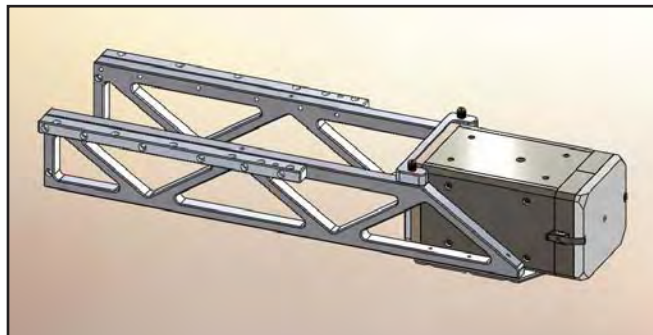
OMEGA EP

- LLNL Electron-positron proton spectrometer II
- LLNL BBXRD spectrometer
- LLNL rSPCA pinhole camera
- LLE spherical crystal imager I (SCI)
- ARTEP/NRL electronic readout EP crystal spectrometer
- Oxford University B-dot probe
- LLNL/NRL gamma crystal spectrometer

New diagnostics are available



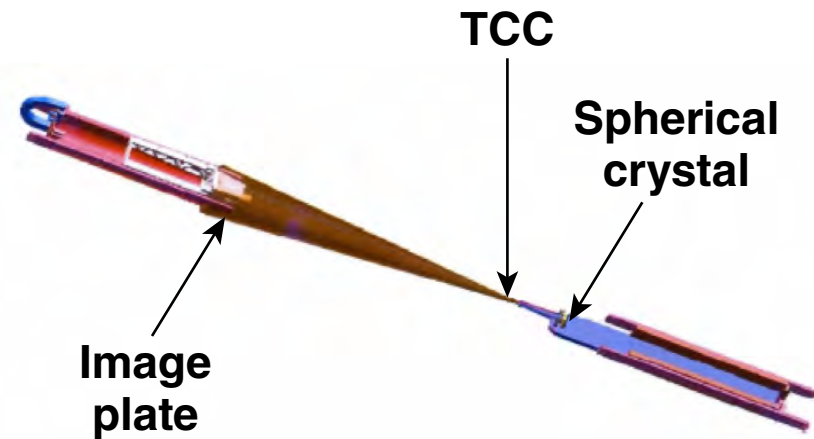
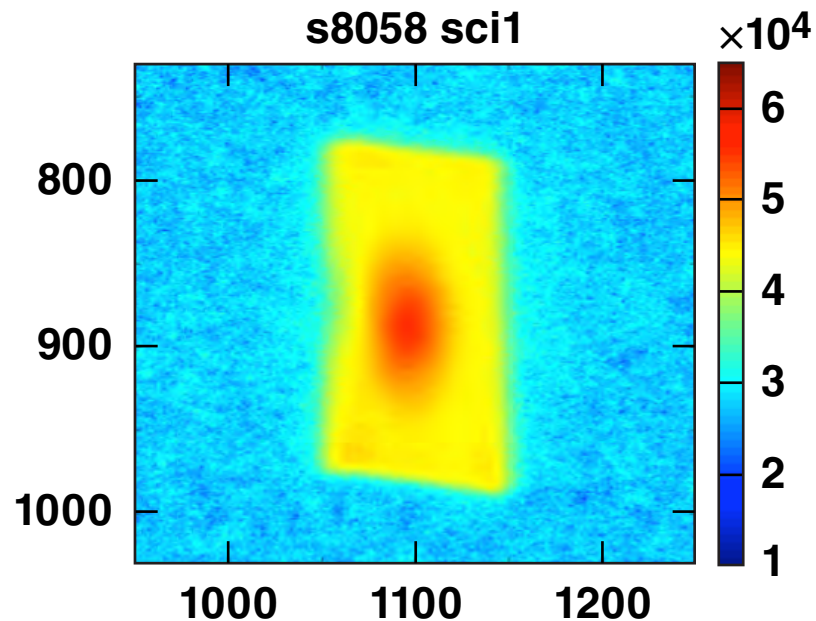
- **Electron–Positron Proton Spectrometer (LLNL)**
 - 1-MeV to 100-MeV design
 - now qualified for use on OMEGA
 - two units are currently based at LLE
 - expect two additional improved units at LLE in FY11



New diagnostics are available (continued)

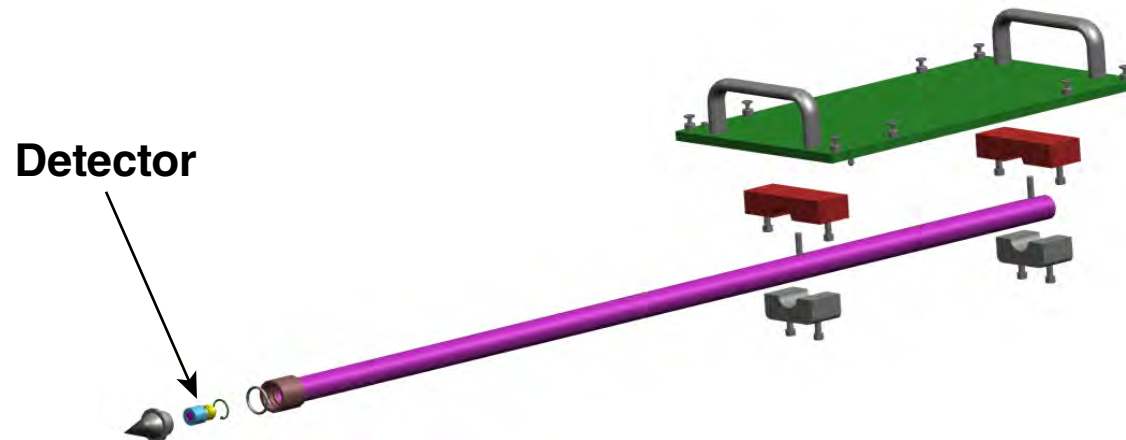


- Spherical Crystal Imager (LLE)
 - prototype design unit deployed
 - time integrated 8-KeV imaging
 - production design in FY11



New diagnostics are available (continued)

- **TIM-Based Time Resolved Neutron Detector Platform (LLE)**
 - deploys new CVD or DDRIC detectors
 - minimizes qualification requirements for new detectors



Improvements have been implemented to increase availability and sustainability



- A second image plate reader has been deployed
- Enhanced beryllium management and monitoring
- Improved diagnostic storage systems

More improvements are planned for the upcoming year



- **Online access to Equipment Qualification Document packages**
- **Diagnostic Users' Guides for more instruments**
- **Integrated diagnostic-timing management system**

Many new diagnostics are in the queue today for FY11



OMEGA

- LANL imaging Thomson spectrometer
- Evolved proton film pack (NTA)
- CEA XCCS collimator
- Sydor vacuum CCD
- Thomson alignment cart
- Spherical crystal imager for OMEGA
- DEMIN II
- EMI resistant TIM cabling
- SGEMP solar array diagnostic
- SPCA upgrade
- PTD ROSS upgrade
- P10.8S15 XRFC frame II
- Cryogenic proton radiography module
- Diamond XR detector
- PJX upgrade
- LLE TIM TPS

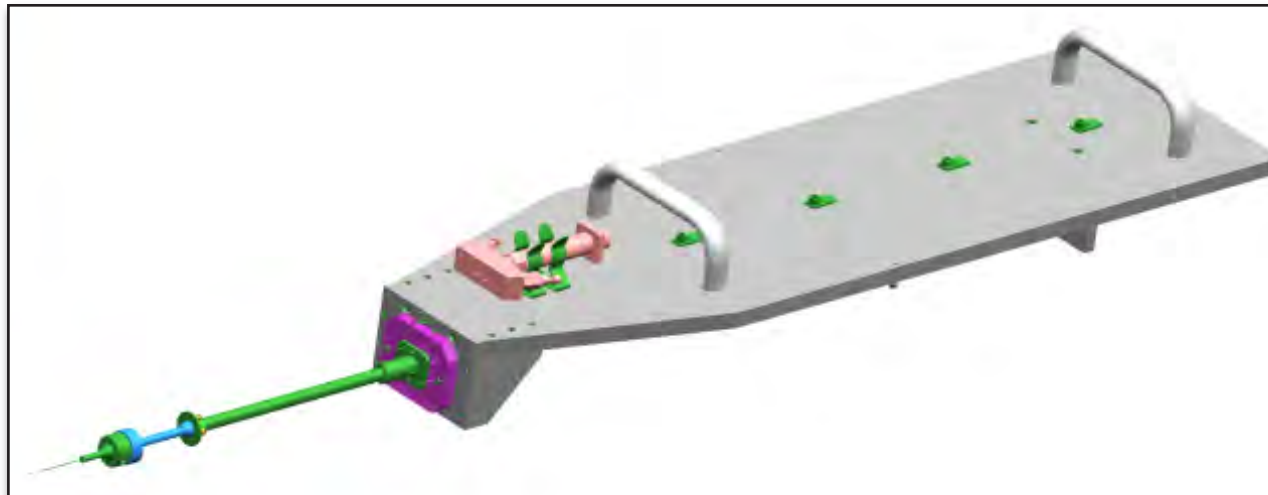
OMEGA EP

- 2nd generation spherical crystal imager
- 4ω probe beam laser
- 4ω diagnostics system
- Evolved proton film pack (NTA)
- Flower test object collimator modification
- CEA XCCS spectrometer
- CIVH spectrometer
- EMI resistant TIM cabling
- Pulsed calibration system for NBI
- nTOF liquid scintillator
- TC light timing diagnostic
- Optical Transition Diagnostic
- OSAKA University electron spectrometer
- LLE TIM TPS

Diagnostics now in qualification



- **LLE TIM based Target Positioner**
 - will deploy on OMEGA and OMEGA EP
 - compatible with LLE and LLNL-Nova target mounts
 - will support LLNL pressure transducer system

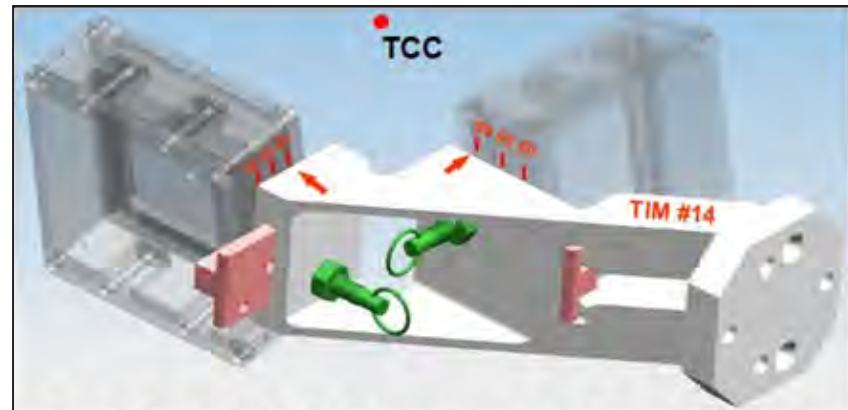
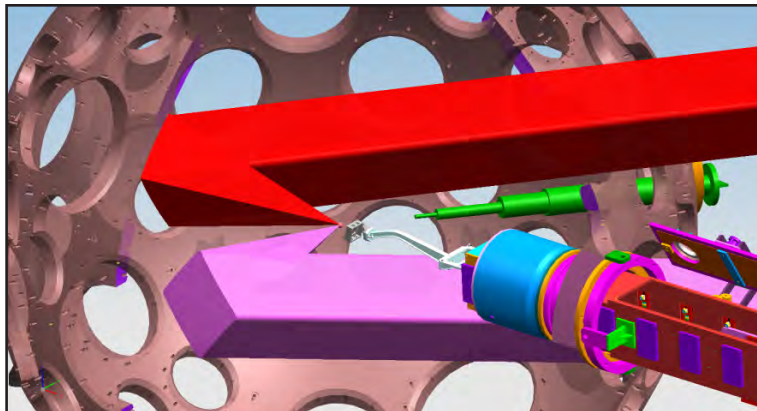
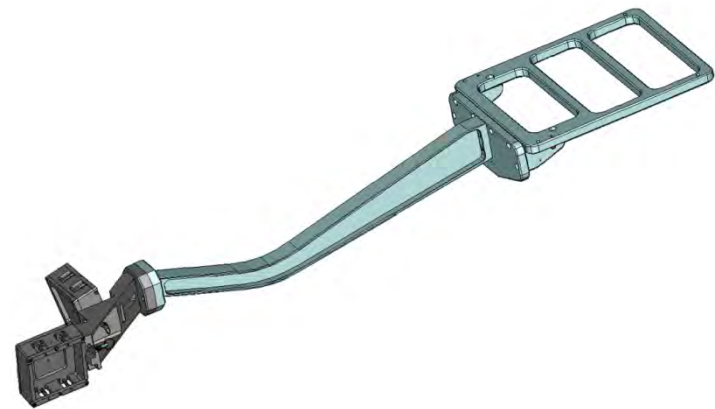


Diagnostics now in qualification (continued)



- **LLE Evolved Proton Film Pack (near target arm)**

- will deploy on OMEGA EP
- replaces LLNL PFP 2
- improved geometry
- increased filter capacity
- more configurations
- improved operating economies



OLUG recommendations for high-complexity projects are being addressed



- **Planar cryogenic target capability on OMEGA EP**
 - expect implementation in FY13
- **Gas-jet target capability on OMEGA EP**
 - expect implementation in the FY13+ period
- **20-MeV gamma spectrometer**
 - expect implementation in the FY13+ period

Summary/Conclusions

LLE is responding to the OLUG 2010 findings



- Diagnostic information availability has been improved
- New diagnostics are available
- Expect continued enhancements in the future

OLUGS
Diagnostic User's Guide

XRS Spectrometer

Summary: The XRS spectrometer is a TM mounted, time integrated, single channel Rowland Circle X-Ray spectrometer that supports the use of a variety of crystals to record X-Ray spectra ranging from 600 eV to 25 KeV.

Instrument Specialist: Sarah Yasuda (ysuda@le.rochester.edu)

Specification	Q	QEP	Notes
Locations	TM40, L.A.A.A.	TM40, L.A.A.A.	Not attached on
Recording media	File (Bufile, QEP) or Image Plate	File (Bufile, QEP) or Image Plate	Image Plate is supplied by LLE. Be authorized. Typical
Filters	As listed should not filter	As listed should not filter	0.005" Be as filter peak
Sites	250mm - Same topocr	250mm - Same topocr	Right right side: Positive entry data possible

Available Energy (KeV) Ranges (one per XRS)

K1 is minimum and K2 maximum of range

Crystal position	K1	K2	K1	K2	K1	K2	K1	K2
Si	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ge	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
As	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Se	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Br	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Kr	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Rb	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Sr	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Zr	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Mo	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ag	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Cd	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Sn	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Sb	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Te	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
I	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Xe	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
La	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ce	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pr	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Nd	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pm	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Sm	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Eu	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Gd	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Tb	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Dy	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ho	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Er	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Tm	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Yb	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Lu	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Hf	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ta	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
W	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Re	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Os	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ir	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pt	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Au	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Hg	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Tl	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pb	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Bi	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Po	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
At	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Rn	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ac	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Th	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pa	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
U	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Np	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pu	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Am	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Cm	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Bk	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Cf	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Es	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Fm	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Md	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
No	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Lr	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Rf	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Hf	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ta	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
W	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Re	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Os	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ir	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pt	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Au	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Hg	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Tl	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pb	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Bi	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Po	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
At	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Rn	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ac	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Th	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pa	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
U	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Np	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pu	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Am	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Cm	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Bk	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Cf	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Es	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Fm	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Md	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
No	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Lr	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Rf	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Hf	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ta	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
W	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Re	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Os	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ir	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pt	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Au	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Hg	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Tl	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pb	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Bi	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Po	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
At	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Rn	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Ac	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Th	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Pa	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
U	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Np	0.016	0.016						