University of Connecticut
Department of Physics

College of
Liberal Arts and Sciences

October 15, 2015

Dr. Tom Settersten
Chemical Sciences, Geosciences & Biosciences Division
Office of Basic Energy Sciences, SC-14
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

Dear Tom,

Please find enclosed the final report regarding the proposal Grant**:** SISGR PROGRAM1, No. DE-SC0002004 entitled "***Advanced Instrumentation for Ultrafast Science at the LCLS*** " which was awarded between 09/15/09 - 09/14/11. I had however obtained no-cost extensions to finish the construction of the multi-users instruments since they required detailed engineering and long lead time to receive parts, detectors, mirrors as well as engineering time from the Linac Coherent Light Source at SLAC National Laboratory.

The awarded funds have been spent, the instruments are ready and have been utilized by scientists and the last instrument is being assembled and scheduled to be commissioned at the LCLS during March 2016. Beamtime at LCLS is very hard to obtain so it isn't unusual to wait before obtaining commissioning time. The other instruments were successfully commissioned using the LCLS in the summer and the fall of 2013. Experimental projects have been submitted to publications and two manuscripts resulting from the commissioning and describing the instruments are almost ready to be submitted. We also gave several presentations at national and international conferences describing the new facilities at the LCLS.

The instruments we built with the SISGR grant have already been used by 12 LCLS approved experiments (Schlichting, Bostedt, Picon, Gorkover, Rohringer, Stohr, Marangos, Cavalieri, Doeppner, Berrah and some PI used the instruments several times). In fact, *all experiments* scheduled at the AMO hutch use the newly built instruments with this SISGR grant. Of course there were many more proposals for beamtime requesting the use of the instruments but only less than 20% of proposals are approved. Thus, the great news is that the instrumentation is in great demand and well utilized.

The instruments are multi-users and are thus available to any scientist who request them for their research from the physics, chemistry, condensed matter physics and biology communities. Furthermore, the instruments can be used at any LCLS endstations and in particular at the AMO and the SXR hutches at the LCLS.

One unforeseen great news, is that the instruments we built are perfectly tailored for the LCLS II.

Below is the final report. If you need any further information, please let me know.

On behalf of the broad scientific user community, thank you for your support of LCLS-based research.

Best Regards,

Nora Berrah
Professor, Department of Physics
University of Connecticut
Storrs, CT 06269-3046
phone 860-486-0439
e-mail: nora.berrah@uconn.edu

No. DE-SC0002004

Advanced Instrumentation for Ultrafast Science at the LCLS

FINAL REPORT

For the period 09/15/09 - 09/14/15

Nora Berrah
Principal Investigator

Department of Physics
University of Connecticut
Storrs, CT 06269-3046

October 2015

Prepared for

the U.S. Department of Energy

Office of Science
Basic Energy Sciences
Division of Chemical Sciences

Grant No. No. DE-SC0002004

TABLE OF CONTENT

I. Final Report

This report summarizes the construction of instruments supported by the SISGR PROGRAM1, No. DE-SC0002004, entitled "***Advanced Instrumentation for Ultrafast Science at the LCLS*** " with the budget period of 09/15/09 - 09/14/15. The experimental systems described below have been ready and have been utilized by users at the LCLS. The instruments enable state-of-the-art experiments across a wide variety of scientific areas ranging from atomic, molecular and optical (AMO) physics, chemistry, warm dense matter (WDM), surface physics, condensed matter physics and biological and inorganic particle imaging.

The instruments are: **1)** An x-ray split and delay (XRSD) tool to allow time-resolved studies using x-ray pump-x-ray probe experiments. This system has been used in experiments providing *jitter-free identical temporal profiles*. **2)** An experimental system called LAMP which consists of two main chambers housing several detectors. LAMP allows for: **A)** Ion-ion coincidences and electron imaging through two velocity map imaging (VMI) detectors in a COLTRIM style for spectroscopy experiments. They have already been used in experiments**. B)** Imaging through two pn-CCD detectors for scattering experiments and have already been used in experiments. **C)** High resolution fluorescence measurements using a soft x-ray spectrometer through the detection of photons for spectroscopy experiments. This last spectrometer will be ready by December 2015 and will be commissioned at LCLS March 2016. These three detection schemes, provide complementary capabilities and allow for complete experiments in a wide range of scientific topics. In addition, the LAMP chambers were built to allow the future opportunity to attach other detectors users may want to utilize for their experiments such as for example the Swedish 2 m long magnetic bottle spectrometer. **D)** A stable optical laser in-coupling system to the LAMP chambers in order to use optical laser systems for optical laser-x-ray pump-probe experiments. This system has also been used in experiments.

1) The X-ray Split and Delay Instrument

A two mirrors based "x-ray split and delay" (XRSD) to enable time-resolved research via x-ray-pump – x-ray-probe experiments was designed and built. It represents a simpler version compared to the more expensive 8 mirrors device which we designed in the fall of 2009. The LCLS was initially interested to contribute to our SISGR funds to build the 8 mirrors design but they couldn't provide the required funds and we didn't chose to use all of our funds for just this instrument. The 8 mirrors device will have allowed a wider photon energy range to be covered (up to 4 keV). The present 2 mirrors device covers photons energy from 500-1800 eV. The merit of the 8 mirrors device was highlighted at the LCLS II science case workshop, February 2015, to be a device to consider building for LCLS II.

The optical x-ray split and delay divides the LCLS x-ray pulse into two portions, delaying one by an arbitrary time, and recombining them at the sample for x-ray pump x-ray probe experiments on the AMO or SXR beamlines. The instrument is based on an edge-polished mirror design, using grazing incidence mirrors to cover an energy range up to 2000 eV. Two mirrors located immediately after the AMO Kirkpatrick-Baez (KB) mirrors will split the FEL wavefront; one of these mirrors will be moved and rotated to produce a variable delay. Because pump and probe pulses are produced from the same FEL pulse, they are transverse-coherent and identical in temporal structure, a *major advantage* of an all optical split and delay system.

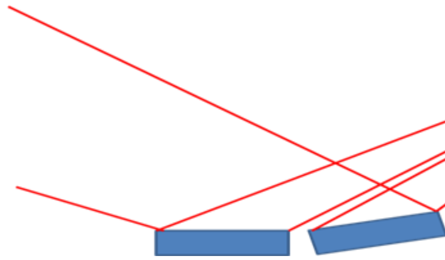

Fig. 1. *Schematic of 2-mirror split and delay principle*

Principle of Operation

The proposed split and delay system utilizes two plane mirrors in grazing incidence. Like the existing soft x-ray optics, these mirrors use B_4C coating and operate at a grazing angle near 14 milliradians to achieve very high reflectivity in the 300 eV to 2K eV photon energy range. In order to produce a controlled delay and maintain overlap in the focus, one mirror (at right in Fig. 1) is translated and rotated while maintaining spatial overlap in the focus. The geometry of the two beam paths is drawn in Fig. 2, and the corresponding equations for the path difference and mirror angle are given in Eqn. 1. The distance from the first mirror edge to the focus is labeled a, the distance from the first mirror edge to the second mirror edge is labeled b, and the mirror angles of incidence are $\theta_1/2$ and $\theta_2/2$.

$$\Delta(path) = \frac{ab}{2(a-b)}\theta_1^2 \qquad\qquad \theta_2 = \frac{a}{a-b}\theta_1 \qquad (1)$$

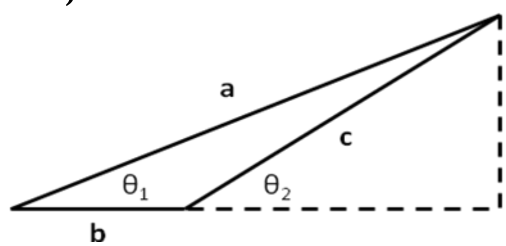

Fig. 2. *Geometry of the two beam paths*

As an example, if the first split mirror edge is located at a=1.25m before the focus, at θ_2=28 milliradians, a mirror edge separation b=0.10m produces a path difference of 43 microns (142fs delay) and θ_2=30 milliradians. At this angle, photons up to 1900eV energy reflect off the second mirror with >90% efficiency (data from CXRO.) Increasing b to 0.20m allows delays up to 311fs for photon energy below 1700eV while maintaining the second mirror reflectivity above 90%. While it is not possible to scan this device through zero delay to negative delay values, the delay can be as small as 7 fs assuming a 5mm mirror separation to allow for a B_4C 'chin guard' to protect the second mirror edge from the incident FEL light. The minimum delay is small enough to allow pump-probe experiments with delays in the range of the Auger lifetimes of many atomic systems. The smallest delay we can achieve will be 0 fs, and the maximum we plan at high photon energies is 100fs. For significantly lower photon energy, longer delays are possible, but this hasn't been defined in detail so far (we will try to make sure that the mirror rotation range allows longer delay times).

Delay Control and Calibration

Producing a controlled delay with micron-scale overlap at the focus requires accurate measurement of the horizontal position and angle of the two mirrors. The required measurement accuracy is produced using commercially available laser interferometer alignment devices (e.g. Renishaw RLE20.) Translation of the second mirror is produced by a commercial precision motor stage, while angle adjustment would be provided by an actuator similar to the SOMS tilt mechanism. All motors are out of vacuum, to minimize any possibility of vacuum degradation.

The initial alignment and delay calibration of the device used standard femtosecond optical laser techniques with the NEH 800nm Ti:Sapphire laser. This calibration was performed in the laser room, and did not impede beamline operations at the AMO hutch. Infrared pulses from the NEH laser are directed through the split delay mirror system. The infrared pulses are split by the edge-polished mirrors, and cross in a second harmonic generation crystal (e.g. Type I BBO) at the nominal working distance for the AMO focus. When the pulses overlap in space and time in the crystal, the 2^{nd} order autocorrelation of the two pulses emerge from the crystal at half the angle between the two beams, and are spatially separated from self-generated harmonic light. The 400nm autocorrelation light is isolated from the 800nm laser fundamental with a color glass filter (e.g. Schott BG-39) and collected on a photodiode. As the delay is varied by translating and rotating the second split/delay mirror, the autocorrelation signal intensity decline as the product of the intensity of the two pulses in the overlap region. Both the energy and pulse duration of the NEH Ti:sapphire laser system are appropriate for this measurement. This method allows calibration of the time delay, and calibration of the mirror tilt motion to maintain overlap of the two pulses.

Controls Interface

The controls required for the operation of the mirror split and delay system consist of position control on three axes, tilt control on two axes, and six channels of position readout to monitor the mirror alignment. These controls were bundled into one software GUI which produces the desired delay and monitors position.

Installation

Centering the split/delay system at a=1.25m before the focus is compatible with operation of the AMO K-B mirrors at approximately 1.7m focal length, with an overall length of 0.7m for the split/delay system. In order to use the system, the AMO diagnostic chamber would be temporarily removed and the AMO chamber repositioned 0.7m downstream of its present location.

Commissioning

1. The XRSD was successfully commissioned and has been used in approved experiments. A publication has been accepted at Nature communication (C. E. Liekhus-Schmaltz, I. Tenney, T. Osipov, A. Sanchez-Gonzalez, N. Berrah, R. Boll, et al., P.H. Bucksbaum, V. Petrovic et al.,“Ultrafast Isomerization Initiated by X-Ray Core Ionization”).

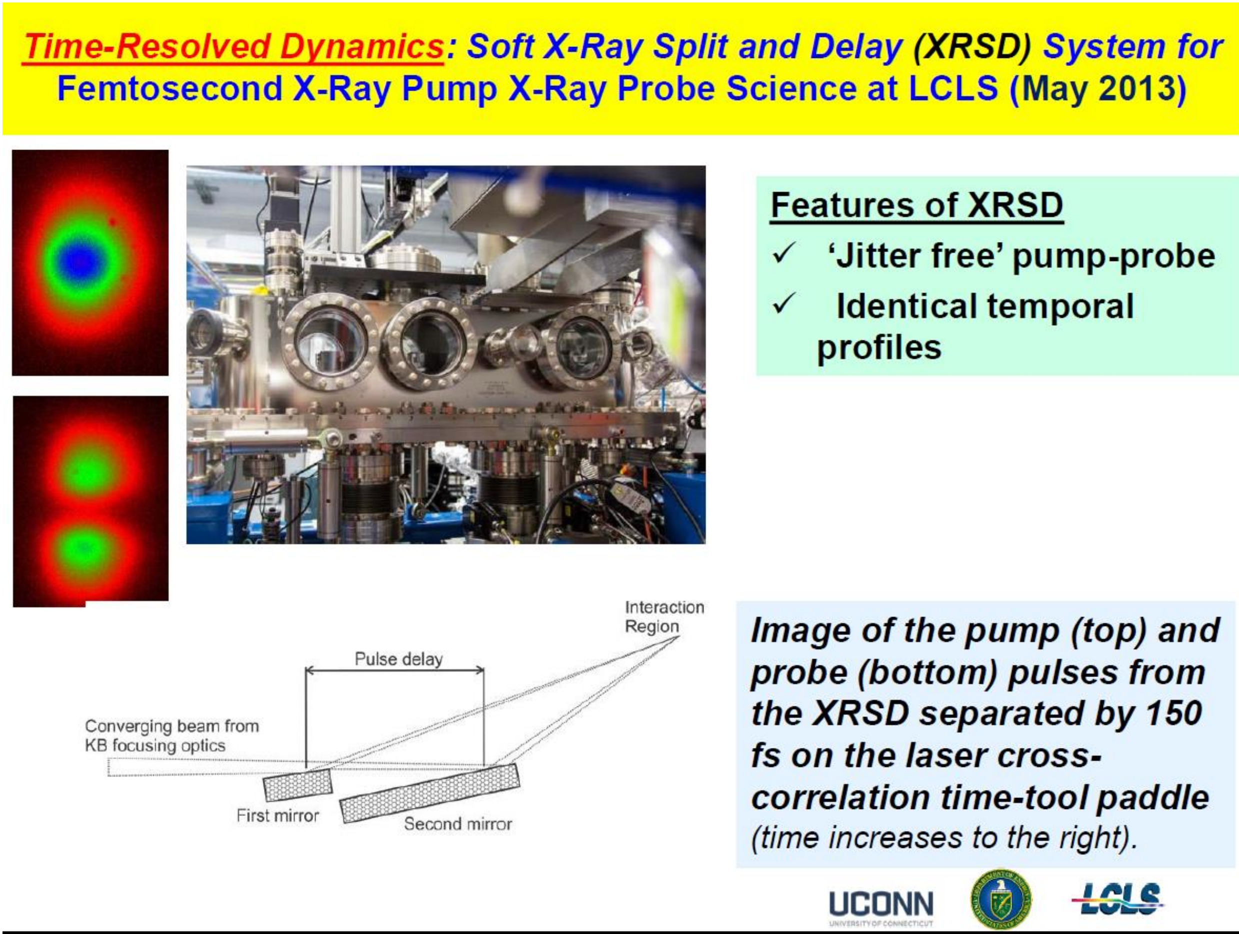

***Fig. 3**. The XRSD instrument picture (top centre) showing the finished device. The single pulse is shown at the top, left of the figure with the two split pulses below the main pulse. The schematic of the delay and the recombination of the two pulses are also shown.*

2) <u>The LAMP Multi-Suite Instruments</u>

The new highly advanced end-station, LAMP, is a second generation end-station after the CAMP system [1] built by the Max Planck Society. LAMP significantly advances the present state-of-the-art AMO instrumentation, enabling structural dynamics experiments across a wide range of science areas. This multi-purpose end-station supports experiments ranging from atomic, molecular and optical (AMO), to chemistry, warm dense matter (WDM), surface physics and biological and inorganic particle imaging.

LAMP has been successfully commissioned and is now available to all scientists at the LCLS. While the end-station resides at the Atomic, Molecular and Optical (AMO) hutch, its component detectors can be used at a variety of different LCLS chambers located at different hutches at the LCLS. The LAMP end-station which is the product of collaborative efforts, consists of the multitude of extremely modular components providing great flexibility when it comes to meeting users experimental requirements and specifications. The ultra-high-vacuum (UHV) end-station supports various sample delivery systems, including atomic, molecular and cluster pulsed and continuous jets, metal vapor, liquid jets and aerosols.

A) LAMP houses the unique double-sided spectrometer based on velocity map imaging (VMI) or also called reaction microscope (REMI/COLTRIM) that supports elaborate research ideas and experiments requiring simultaneous electron measurement with coincident measurements of ions produced under the extreme conditions of interaction of high intensity FEL beam with matter.

B) LAMP houses movable large-format, high-speed pnCCD detectors that allow detection of scattered photons ideal for crystal and biological samples.

C) LAMP houses a soft x-ray spectrometer which enable high measurement fluorescence. This detection scheme is very clean since it is not hampered by the background. This detection scheme will be used for condensed matter, liquid as well as gas-phase experiments. It is portable so it can be shared by all hutches and in particular the SXR and AMO hutches.

D) LAMP has a collinear optical laser in- and out-coupling units for alignment and for optical laser pump/probe experiments as well as an OPA unit and optics components for providing pump/probe pulses at various wavelengths. These devices have been purchased with this grant

Figure 1 shows the general schematic of the overall LAMP systems embedded in the AMO photon beamline at the AMO hutch at LCLS. The FEL passes the AMO beamline coming from the right. It 1) passes through the LCLS original KB mirrors which focus the FEL beam into the interaction chambers. 2) It passes through the newly built laser in-coupling system (for optical laser-FEL pump-probe experiment). 3) It passes through the first LAMP chamber (C1) which houses a supersonic jet coming out of the page, as well as the double VMI/REMI/COLTRIM detectors. A gate valve separate the first C1 chamber from the second C2 LAMP chamber which houses the two pnCCDs detectors. The interaction chambers allow optimum flexibility with large CF250 flanges and a large number of smaller flanges aligned to the interaction point in the centre of the chamber for cameras, laser feed in, additional time-of-flight spectrometers etc. Additional instrumentation required by users can be implemented via the large ports. The scattering chamber is designed to be as short as possible and supports a focussing length for the FEL radiation of less than 1 m. This includes differential pumping stages and in-coupling optical devices for collinear lasers for pump-probe experiments.

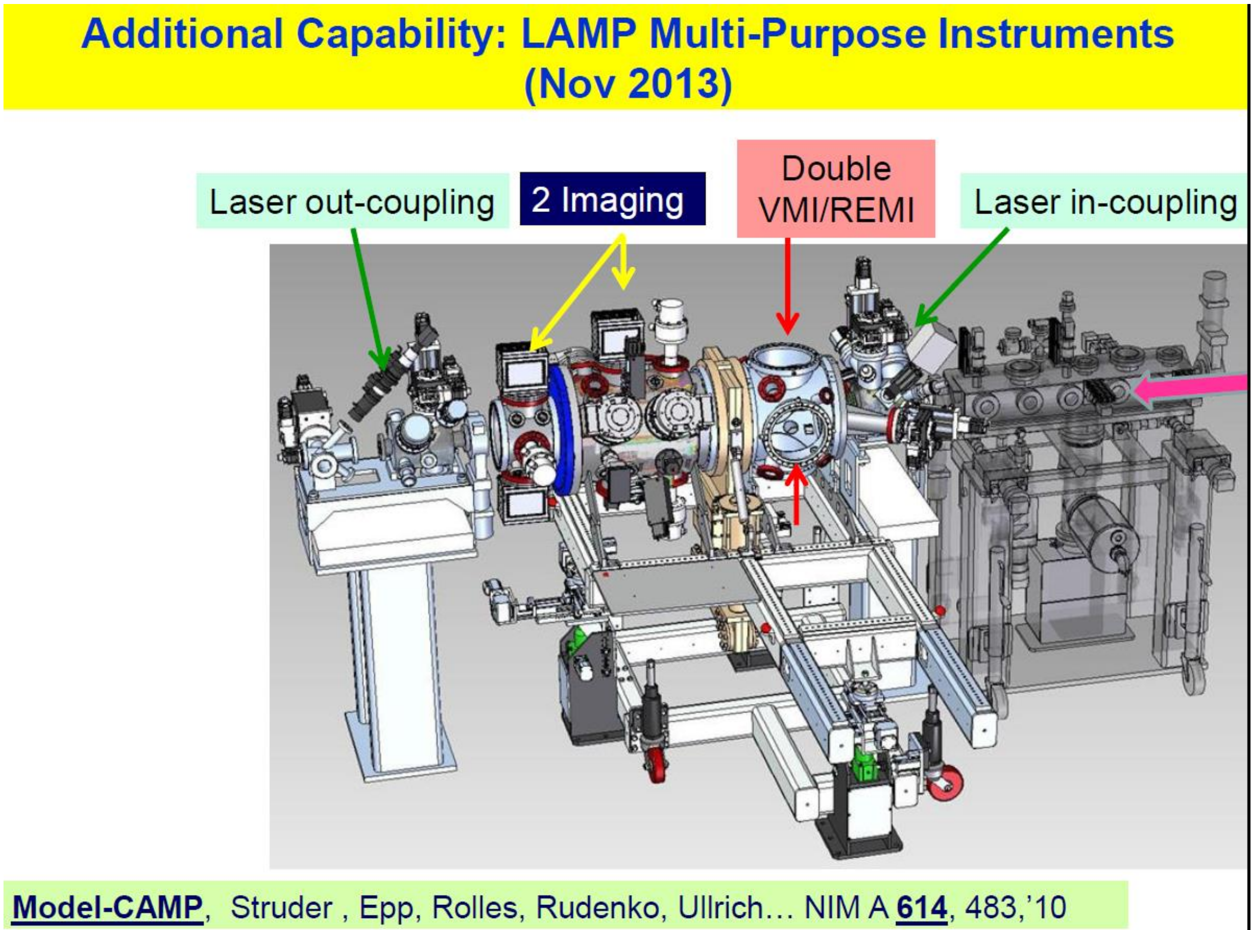

Fig. 1. *Schematic of the beamline at the AMO hutch, showing the suite of LAMP instruments.*

Figure 2 shows more details regarding the LAMP chambers and stand which were also built with this grant. The stand allows perfect alignment of the chambers in the xyz directions with the FEL beam.

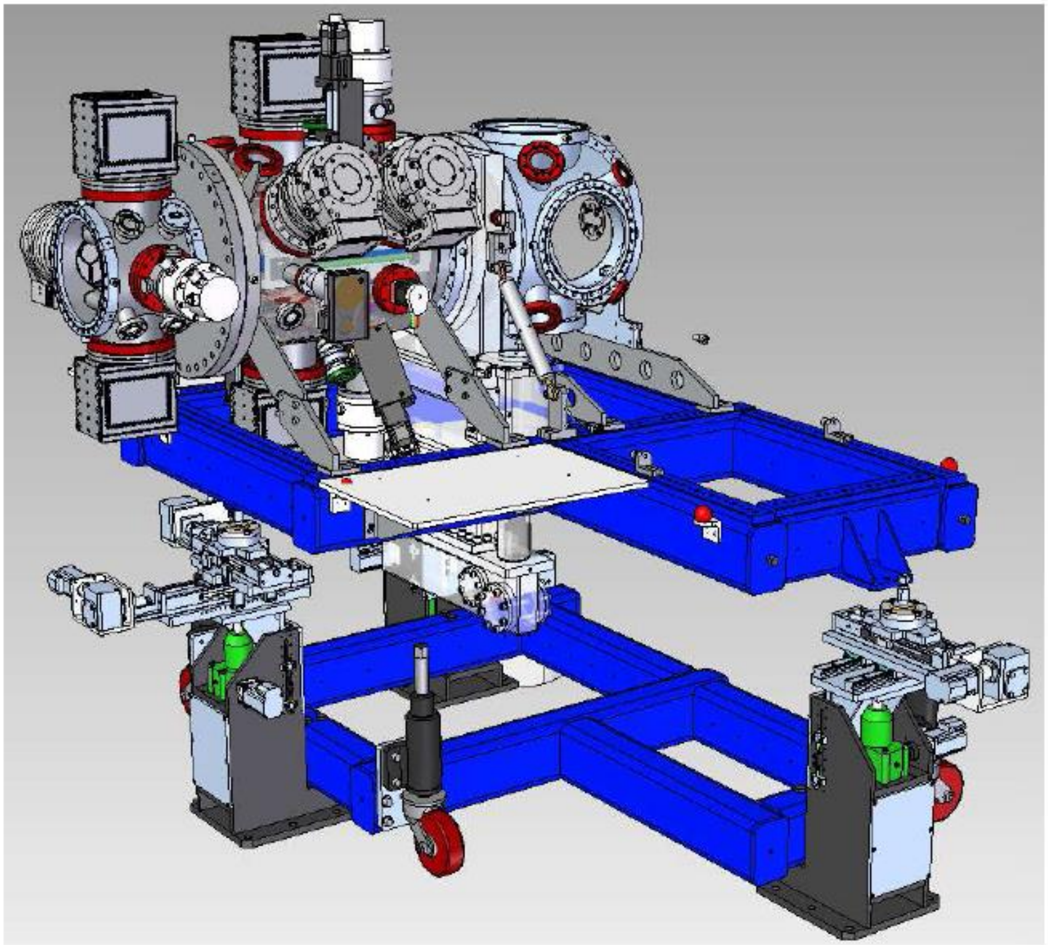

Fig. 2*. Major components of the LAMP instrument: Stand (bottom); (from right to left) Interaction chamber|C1;400mm ID gate valve; pnCCD chamber | C2 (C2-1 | for the front pnCCD, C2-2 | for the rear pnCCD detectors).*

A) LAMP double VMI/REMI/COLTRIM spectrometers

Figure 3 shows the double VMI spectrometers. The left side shows the schematic of the spectrometers while the right side shows the picture when it was introduced into the vacuum system. The detectors are equipped with large-area MCP readout detectors with either delay-line or phosphor screen readout. Figure 4 shows the data collected with the ion VMI spectrometer in the case of CO where coincidence events were recorded. Clearly the spectrometer works very well since we were able to reproduce the CO experiment during the commissioning beamtime. This instrument has been used for many experiments since its commissioning in November 2013.

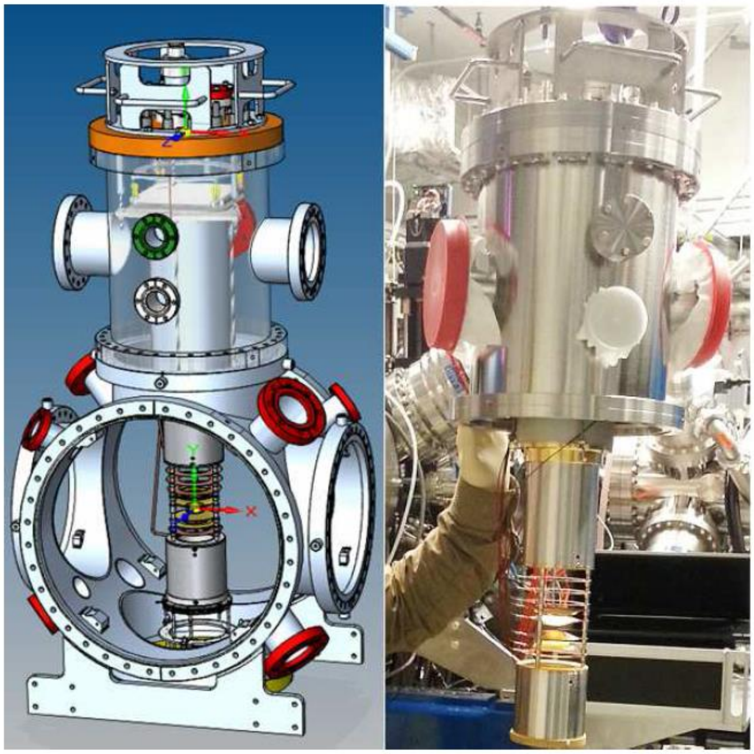

Fig. 3. *LAMP double VMI spectrometer with the extension adapter spool: Solid Edge schematics inside C1 (left); in the process of actual installation (right) in the LAMP vessel.*

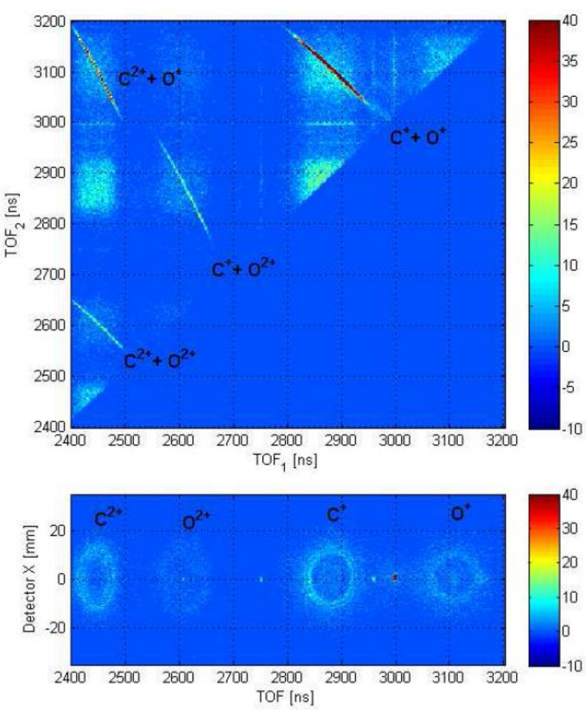

Fig. 4. *Typical PIPICO spectrum (top) collected in the ion-ion coincidence experiment using the VMI spectrometer. Projection of the momentum space onto spatial-coordinate vs. TOF plane (bottom) constructed from the data collected by the delay-line detector*

B) LAMP large area x-ray pnCCD detectors

The system we built has great flexibility to mount the pnCCDs in the interaction chamber. They can be placed either at shortest distances with respect to the interaction point of 1 cm (CCD1) and 50 cm (CCD2). Alternatively, by implementing extension tubes any greater distance can be realized independently for both detector planes. The setup allows also fluorescence light detection but the detected photons are broad and are not resolved. This is why we built a soft x-ray spectrometer. The pnCCD detectors are tailored for scattering experiments.

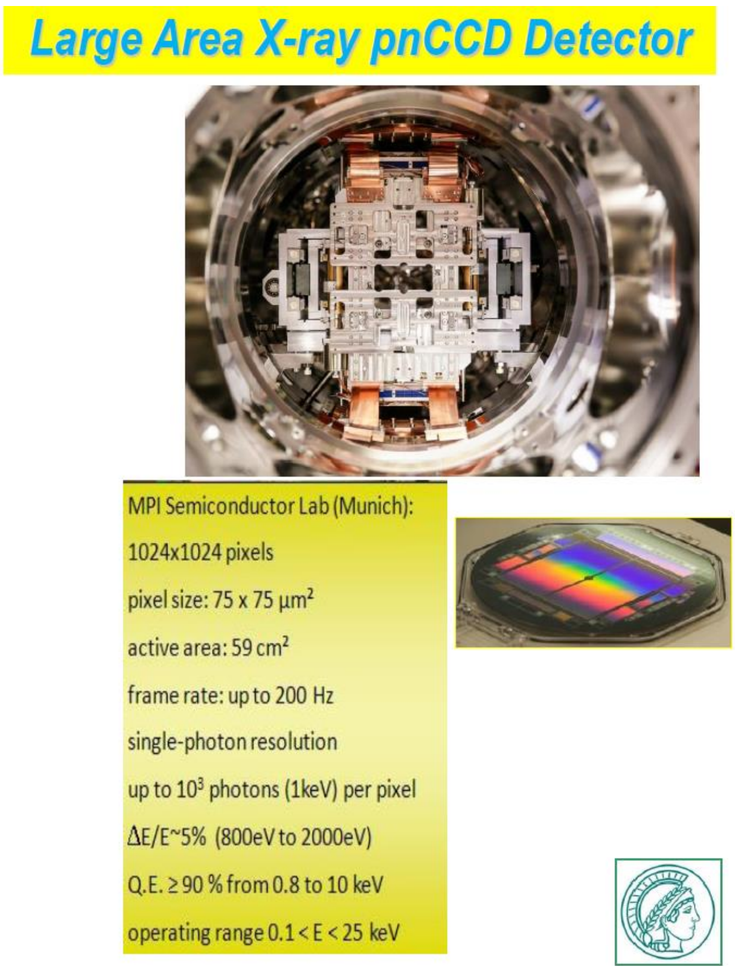

***Fig. 5**. (top) Sophisticated mounts for the pn-CCD detectors fabricated with this grant. Bottom) Large area pnCCD detector (purchased with LCLS funds from the Max Planck Society) image. We have two such detectors to detect signal at small and large scattering angles.*

C) LAMP Soft X-ray Spectrometer

For high-resolution fluorescence spectroscopy we have designed and built a soft x-ray spectrometer. The spectrometer itself has been shipped to SLAC and has been un-crated. It passed the vendor acceptance test and met every aspect of the engineering specification document, so it is expected to perform well with regard to precision and mechanical resolution. The main custom chamber to adapt the spectrometer to the LAMP endstation for all associated pumping, gauging, and pressure safety devices is out for bid. The M1 mirror is due in by the end of October. The Grating is expected to be delivered by the end of December. The custom 6-degree-of-freedom mount assembly is in the final stages of design and all drafts have been generated for all parts. A final design review needs to be held, and then those parts will be procured, with a desired delivery and assembly start date of Mid-January. Commissioning with the LCLS beam will take place in early March (11^{th}) at LCLS.

Below in Figs. 6 and 7 are CAD models showing the spectrometer installed on the LAMP vessel attached to the C1 chamber.

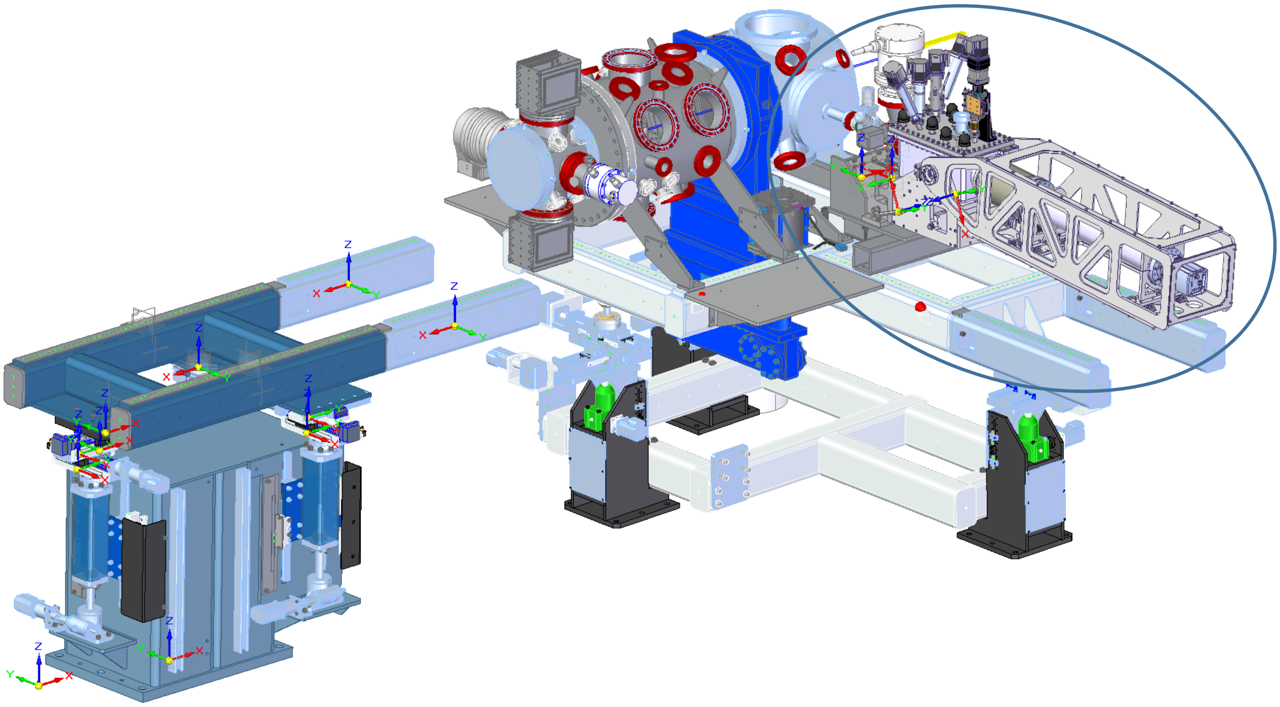

Figure 6. *CAD model showing soft X-ray spectrometer installed on AMO LAMP vessel on the C1 chamber*.

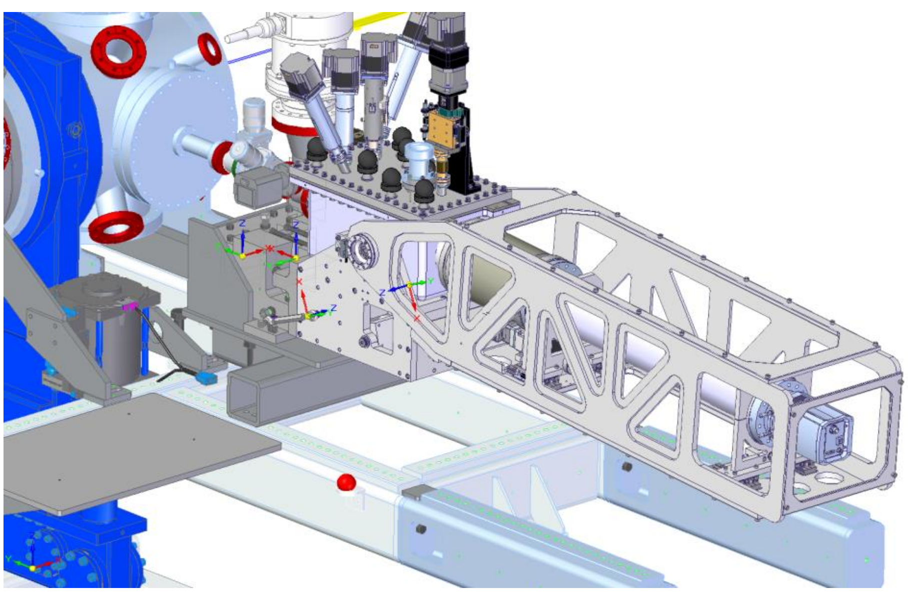

Fig. 7. *Close-up view of CAD model showing soft X-ray spectrometer installed on the AMO LAMP vessel; C1 chamber.*

Figures 8 and 9 show the spectrometer main frame as well as the grating mover mechanisms.

Fig 8. *The SX Spectrometer main frame and chamber during final acceptance testing 7-28-2015.*

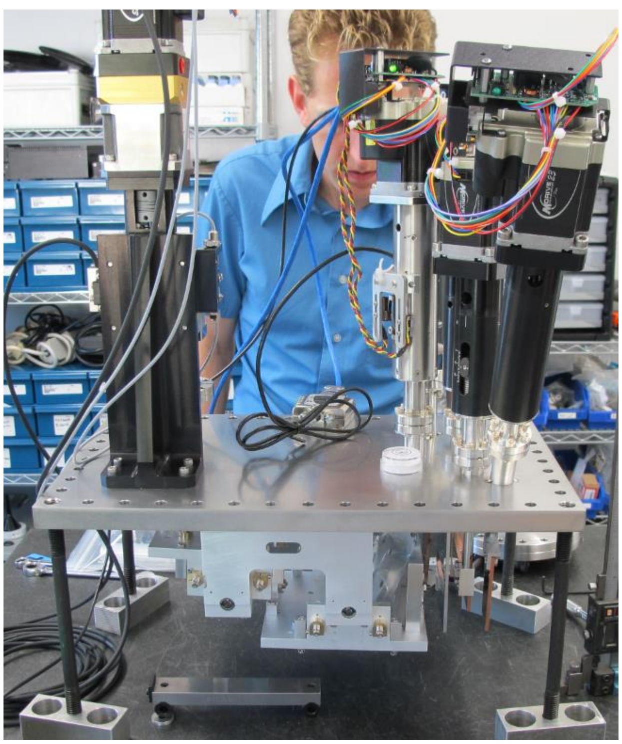

Fig.9. *The SX Spectrometer M1 and Grating mover mechanisms during final acceptance testing 7-28-2015.*

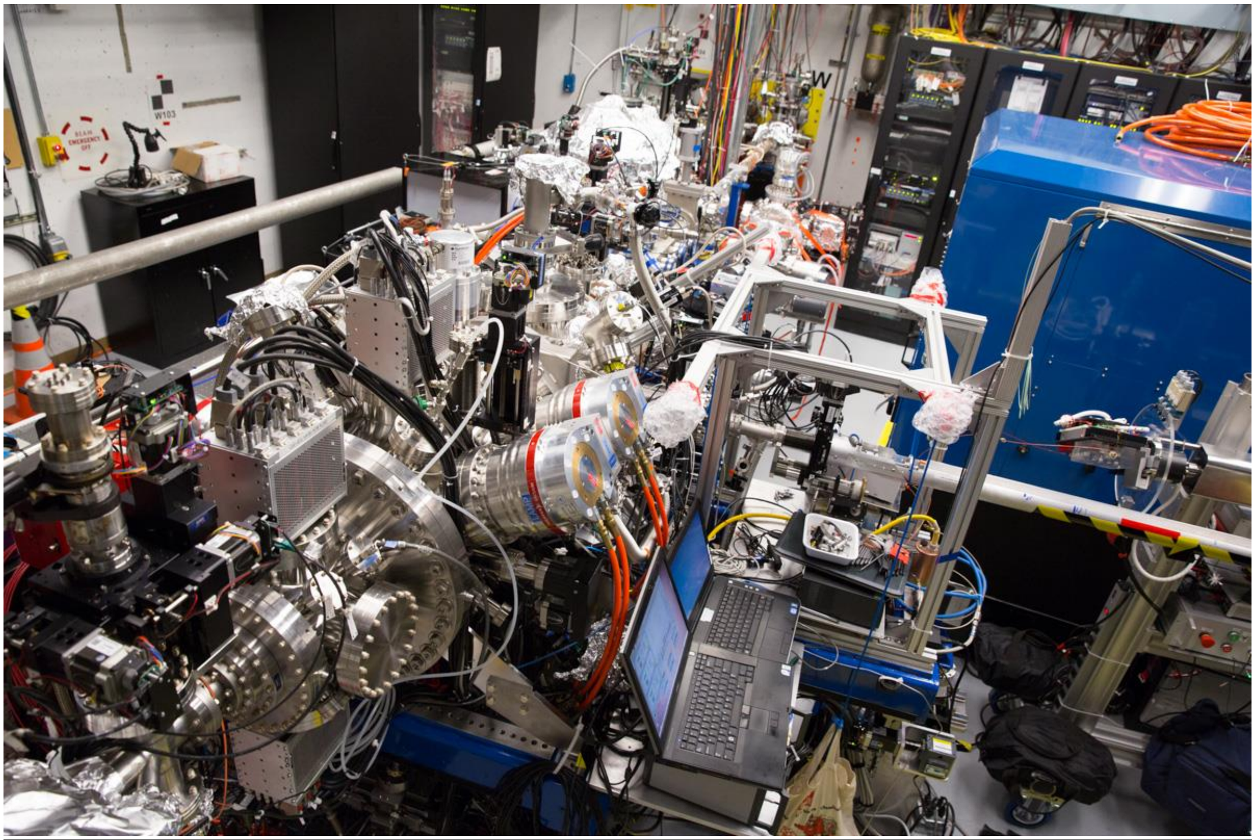

Fig. 10. *Lamp vessels installed in the AMO hutch at the LCLS with the C1 and C2 chambers, detectors and associated apparatus.*

References

[1]. L. Strüder et al., Nucl. Instr. Meth **614,** 483 (2010)

II. Statement of Unexpected funds.

We have spent all of the funds to purchase or build instrumentation as well as support three postdocs who contributed toward building and commissioning the instrumentation.

III. Personnel

Nora Berrah (WMU/UConn) -PI for Project

Posdocs/Research fellows (WMU/UConn):

1. Dr. Brendan Murphy (11/2009 – 12/31/2013) - Postdoctoral fellow
2. Dr. Timur Osipov (4/2010 – 10/2014) - Research scientist
3. Dr. Hui Xiong (3/2013- 7/2015) -Postdoctoral fellow

LCLS personnel

Instruments scientists: John Bozek, Christoph Bostedt,
Engineer: J-C. Castagna,
Support technical staff: Michelle Swiger and many other engineers and technicians.

Timur Osipov who was a research scientist supported by this grant has taken over the job of John Bozek as the instrument scientist for the AMO hutch.

VI. Publications, Conference Abstracts and Presentations from DOE Sponsored Construction Project

1. C. E. Liekhus-Schmaltz, I. Tenney, T. Osipov, A. Sanchez-Gonzalez, N. Berrah, R. Boll, et al., P.H. Bucksbaum, V. Petrovic et al.,"Ultrafast Isomerization Initiated by X-Ray Core Ionization"(accepted in Nature Comm).

2. Sanchez-Gonzalez, Alvaro; Barillot, Thomas; Squibb, Richard; Kolorenc, Premysl; Agaker, Markus; Averbukh, Vitali; Bearpark, Michael; et al., Berrah, Nora; Bucksbaum, Phil; Ueda, Kiyoshi; Feifel, Raimund; Frasinski, L; Marangos, J, "Auger electron and photoabsorption spectra of glycine in the vicinity of the oxygen K-edge measured with an X-FEL" (accepted in J. Phys. B, 2015).

3. A. Picon, C. S. Lehmann, C. Bostedt, A. Rudenko, A. Marinelli, T. Osipov, D. Rolles, N. Berrah, C. Bomme, M. Bucher, G. Doumy, B. Erk, K. R. Ferguson, T.Gorkhover, P. J. Ho, E. P. Kanter, B. Krassig, J. Krzywinski, A. A. Lutman, A.M. March, D. Moonshiram, D. Ray, L. Young, S. T. Pratt, and S. H. Southworth, "Hetero-site-specific ultrafast intramolecular dynamics" (submitted to Nature Comm.)

4. C. S. Lehmann, A. Picon, C. Bostedt, A. Rudenko, A. Marinelli, D. Moonshiram, T. Osipov, D. Rolles, N. Berrah, C. Bomme, M. Bucher, G. Doumy, B. Erk, K. Ferguson, T. Gorkhover, P. J. Ho, E. P. Kanter, B. Krassig, J. Krzywinski, A. A. Lutman, A. M. March, D. Ray, L. Young, S. T. Pratt, and S. H. Southworth, "Ultrafast measurements for molecular nuclear dynamics using two x-ray pulses" (submitted to Physical Review Letters).

5. T. Osipov, C. Bostedt, J-C. Castagna, K. R. Ferguson, M. Bucher, S. C. Montero, D. Rolles, A. Rudenko, M. L. Swiggers, and N. Berrah, " LAMP: The New Advanced LInca Coherent Light Source Free-Electron-Laser End-Station (to be submitted to Review of Scientific instrument)

6. N. Berrah, L. Fang, X. Hui, E. Kukk, V. S Petrovic, B. F Murphy, and J. Bozek, "X-ray pulse split and delay device at the LCLS free electron laser facility" (to be submitted to Review of Scientific instrument)

Invited Presentations that included descriptions of the new instruments or were fully focused on the description of the instruments:

1. “Probing fullerenes from within using FELs”, Nobel symposium, Stigtuna, Stockholm, Sweden, June 15, 2015.

2. “Photoionization of C_{60} using the LCLS”, International Conference IWP/RIXS, Erice, Italy, August 2014.

3. “Probing complexity from within using XFELs”, Plenary presentation in Prize Session for Davisson-Germer Award) at the 2014 Division of AMO Physics (DAMOP) conference, Madison, WE, June 2014.

4. “Science with FELs”, Gordon Conference on Multiphoton Ionization, Boston, June 2014.

5. “Probing C_{60} dynamics using the LCLS”, FEL Attosecond conference, U-College London (UCL), June 30, 2014.

6. “Ultrafast phenomena with FELs”, XCLIC, UCL, London, July 3-4, 2014.

7. Molecular dynamics with FELs”, Faraday Discussions, Sheffield, UK, July 8-11, 2014.

8. “Probing C_{60} from within using the LCLS” MPS 2014, Metz, France, July 15-18, 2014.

9. “Investigating extended systems with FELs” GRC in Galveston, TX, February 2014.

10. “Probing complexity using the LCLS and the ALS”, AMOS workshop, October 27-30, 2013.

11. “Probing Dynamics using FELs”, LCLS annual users meeting, SLAC National Laboratory, October 1-4 2013.

12. “Investigating dynamics with FELs”, Plenary talk at the 17th International Symposium on Polarization and Correlation in Electronic and Atomic Collisions, Hefei, China, July 31-August 3, 2013.

13. “Investigating Molecular and Clusters Physics with Ultrasfast and Ulraintense photons”, Invited talk at the 38th International Conference on VUV-X ray Physics, Hefei, China, July 12-18, 2013.

14. “Investigating Dynamics in C_{60}”, ISWAMP-2, ICPEAC satellite, Xi’an, China, 2013.

15. “Physics with ultrafast X-FEL”, Invited lecture at the Ultrafast X-ray Summer School (UXSS), June 11-14, 2013, DESY, Hamburg, Germany.

16. “Cross cutting review in AMO and Dynamics”, Workshop at the Advanced Light Source, April 4, 2013.

17. "Multiphoton X-ray Dynamics in Atoms and Molecules" XXIX Frontiers in Optics/ Laser Science (FIO/LS) 2012, LTu5H.2, Rochester, NY October 2012. Given by B. Murphy, my postdoc.

18. “Probing matter from within using x-ray free electron lasers”, Conference for Undergraduate Women in Physical Sciences (WoPhyS'12) at the University of Nebraska in Lincoln, October 2012.

19. “Molecular Physics with X-FEL” Plenary talk, 2012 EGAS conference, European Group on Atomic Systems, Goteborg (Sweden), July 9-13, 2012.

20. “Probing matter with FELs”, ICTP, Trieste, Italy, March 28, 2013.

21. “Ultrafast Molecular physics with FELs”, Gordon conference on Photoions, photoionization and photodetechment, Galveston, TX, February 12-17, 2012.

22. "Probing Fundamental Processes Related to Plasmas Physics using the LCLS X-ray FEL", Workshop in Paris VI, “2012 Journee Plasmas/Plasma Day”, January 18, 2012, Paris, France

23. “Probing Molecules from Within with the ultra-intense and ultra-fast LCLS, XFEL”, International Workshop on ATOMIC PHYSICS, November 21 - 25, 2011, Dresden, Germany.

24. “Probing Molecules from Within with the ultra-intense and ultra-fast LCLS, XFEL”, International workshop v-FAMC 2011, New Frontiers in Atomic, Molecular and Cluster Physics and Chemistry, Trieste, November 14-15, 2011, Italy

25. “Probing Molecules from Within with the ultra-intense and ultra-fast LCLS, XFEL”, EMMI workshop on Non-Linear Dynamics of Simple Quantum Systems at Extreme Temperature and Intensities”, Darmstadt, Germany October 31, (2011).

26. “Scientific Opportunities with X-FELs”, Finnish synchrotron users meeting, Campere, Finland, Oct 24, 2011.

27. “Probing the Evolution of the Interaction of Molecules with the LCLS X-ray FEL” 2011 X-ray Science Research Gordon Conference, Maine, August 8, 2011.

28. X-Ray FEL Induced Multiple Ionization and Double Core-Hole Production, International conference in photonic, electronic and atomic collisions, ICPEAC XXVII, Belfast, UK, July 28, 2011.

29. Intense FEL-Molecules Physics: Highly charged ions, 17th international conference on atomics processes in plasma, APiP, Belfast, UK, July 20, 2011.

30. “FEL sources Physics”, Jefferson-Lab users meeting, New-Port News, VA, June 6, 2011

31. “First Experiments using the LCLS free electron laser”, CLEO conference, Maryland, May 1, 2011

32. “Ultraintense X-Ray Induced Multiple Ionization and Double Core-Hole Production in Molecules”, Annual German Physical Society, DPG Spring Meeting, March 13-18, Dresden, 2010, Germany.

33. “Observation of Multiphoton Physics: First Experiments using the LCLS X-Ray FEL”, International Conference on Many Particle Spectroscopy of Atoms, Molecules, Clusters and Surfaces (MPS2010, September 4-7, 2010, Sendai, Japan.

34. “X-ray Induced Multiple-Ionization, Dissociation and Frustrated Absorption in Diatomic Molecules”, X-ray Science in the 21st Century, The Kavli Institute for Theoretical Physics (KITP), UC Santa Barbara, August 2-6, 2010.

35. “First Results on Ultra-Fast and Ultra-Intense Studies on Molecular Photoabsorption using the LCLS X-Ray FEL”, 2010 Multiphoton Processes Gordon Conference, June 6-11, 2010.

36. “First Results on Ultra-Fast and Ultra-Intense Studies on Molecular Photoabsorption using the LCLS X-Ray FEL”, Division of Atomic, Molecular and Optical Physics (DAMOP), May 25-29, 2010, Houston, TX.

37. “First Results on Ultrafast and Ultraintense X-Ray Studies of Molecular Photoabsorption using the LCLS Free Electron Laser”, International Workshop on Science with FELs – from first results to future perspectives, March 14-17, 2010, Ringberg, Germany.

38. "X-Ray Split and Delay, 8 mirrors device”, User Community Workshop for the XRSD instrument, LCLS, SLAC, February 2010. Presentation given by Brendan Murphy.

39. "X-Ray Split and Delay", LCLS 2010 User Meeting, LCLS AMO Workshop, October 2010, SLAC, CA. Workshop 6: AMO Science Opportunities and Instrumentation Needs. Presentation given by Brendan Murphy.

40. "Status of the Second Generation Instrument in the AMO Hutch: LAMP", LCLS 2010 User Meeting, October 2010, LCLS AMO Workshop - October 20, 2010. Presentation given by Timur Osipov.

Conference Abstracts:

1. B. Murphy, L. Fang, M. Hoener, E. Kukk, E. Kanter, J. Bozek and N. Berrah, “Multiphoton dissociation of H2S by intense x-ray pulses from the Linac Coherent Light Source FEL" Bull. Am. Phys. Soc. **56**, (5), 87 (2011).

2. B. Murphy, J. Bozek, J-C. Castagna, and N. Berrah, "X-ray Split and Delay System for Soft x-ray Pump/Probe Experiments at the LCLS Free Electron Laser" Bull. Am. Phys. Soc. **56**, 5, page 103 (2011).

3. T. Osipov, D. Rolles, C. Bostedt, J-C Castagna, R. Hartmann, J.D. Bozek, I. Schlichting, L. Strüder, J. Ullrich and N. Berrah, "Next Generation Instrumentation: LAMP - LCLS - ASG - Michigan - Project For Novel Science with the LCLS FEL" Bull. Am. Phys. Soc. **56**, (5), 87 (2011).

4. T. Osipov, L. Fang, M. Hoener, B. Murphy, E. Hosler, C. Bostedt, J.D. Bozek, E. Kanter, S.T. Pratt, S. R. Leone, N. Berrah, "Multiple Ionization and Fragmentation of SF6 Using the LCLS Femtosecond X-Ray FEL" Bull. Am. Phys. Soc. **56**, (5), 103 (2011).

5. T. Osipov, J-C Castagna, C. Bostedt, K. Ferguson, M. Butcher, N. Berrah, “The LAMP instrument at the LCLS”, Bull. Am. Phys. Soc. **60**, (7), 180 (2015).