Appendix A: Workshop Program
SLAC/DESY INTERNATIONAL WORKSHOP ON INTERACTIONS OF INTENSE SUB-PICOSECOND X-RAY PULSES WITH MATTER

WORKSHOP PROGRAM

Thursday, January 23, 1997

8:00 - 8:30 Breakfast

8:30 - 8:40 Welcome - Arthur Bienenstock (SSRL)

8:40 - 9:15 Introduction and Background:
- TTF FEL Source Properties - Gerd Materlik (DESY)
- LCLS Source Properties - Roman Tatchyn (SSRL)

Session 1 (Roman Tatchyn, Chair)

9:15 - 10:00 Experiments with Advanced Photon Sources (I) - Richard More (LLNL)

10:00 - 10:30 Coffee Break

10:30 - 11:15 Experiments with Advanced Photon Sources (II) - Richard More (LLNL)

11:15 - 12:00 Atoms, molecules and clusters in superintense laser pulses
- Kazimierz Rzazewski (Inst. of Theoretical Science, Poland)

12:00 - 1:30 Lunch

Session 2 (John Arthur, Chair)

1:30 - 2:15 Review of Laser Damage of Optical Materials: Scaling from Nanosecond to Femtosecond Pulse Regimes - Brian Newnam (LANL)

2:15 - 3:00 Interactions of intense picosecond VUV pulses with matter - potential experiments during the first phase of the TTF FEL project.
- Jacek Krzywinski (Polish Academy of Science/DESY, Germany)

3:00 - 3:30 Coffee Break

3:30 - 5:00 Discussion Session: Theoretical and numerical work required as backup for 100-1 Ångstrom experiments on present sources and the future LCLS/TF FEL (Richard More, Roman Tatchyn)

6:30 Dinner at Capriccio's Restaurant (non-sponsored)
325 Sharon Park Drive
Menlo Park
Friday, January 24, 1997

8:00 - 8:30 Breakfast

Session 3 (Gerd Materlik, Chair)

8:30 - 9:00 Limiting radiation/matter interactions in focused LCLS beams - Seb Doniach (Stanford University)

9:00 - 10:00 Crystal Optics for the LCLS - Andreas Freund (ESRF, France)

10:00 - 10:30 Coffee Break

10:30 - 11:15 Power considerations for the TESLA FEL: Photon beam transport and monochromatization - Jupp Feldhaus (DESY, Germany)

11:15 - 12:00 Discussion session: Optics and instrumentation design for the actual LCLS and TTF FEL (Jupp Feldhaus, John Arthur)

12:00 - 1:30 Lunch

Session 4 (Andreas Freund, Chair)

1:30 - 2:15 Some ideas on testing LCLS optics without an LCLS - Malcolm Howells (LBNL)

2:15 - 3:00 Bent Crystal Optics for X-ray Flash Sources - Eckhart Foerster (University of Jena, Germany)

3:00 - 3:30 Coffee Break

3:30 - 3:55 Properties of PETRA for the characterization of optical elements for X-FEL - Horst Schulte-Schrepping (DESY, Germany)

4:00 - 5:00 Discussion session: High peak power experiment design for 3rd generation and alternative sources in the 100-1 Angstrom range (John Arthur, Roman Tatchyn)
Appendix B: Workshop Abstracts
Title: Interaction Experiments with Advanced Photon Sources

Dr. Richard More
Lawrence Livermore National Laboratory

Abstract: Experiments with advanced photon sources at LLNL and elsewhere will be reviewed. The talk will include surveys of the physics of interactions of ultra-intense short pulses with matter, experimental techniques, and numerical simulation codes. Possible extrapolations of present work to the 100-1 Ångstrom range will be discussed.

Title: Atoms, molecules and clusters in superintense laser pulses

Prof. Kazimierz M. Rzazewski
Polish Academy of Sciences / Center for Theoretical Physics

Abstract: We have developed a hydrodynamic model of complex systems of charged fermions interacting with very short pulses of electromagnetic radiation. We have applied the method to multielectron ionization of atoms, molecules and clusters. In atoms the method predicts the appearance of intensities of various ion species. In molecules the properties of the Coulomb explosion in strong fields may be explained. In clusters a new mechanism of explosion of consecutive shells of atoms and production of highly energetic ions has just been discovered. Most of the studies to date were done for the optical frequencies of the electromagnetic pulse. In my talk I will compare the results obtained in the optical regime with the ones for X-rays.

Title: Review of Laser Damage of Optical Materials: Scaling from Nanosecond to Femtosecond Pulse Regimes

Dr. Brian E. Newnam
Los Alamos National Lab / Accelerator Transmutation

Abstract: For the past 25 years, laser damage to optical materials has been studied extensively for high peak power pulses in the microsecond to picosecond pulse regimes. In the last few years, a few damage experiments have been also been conducted with femtosecond pulses. We review the
results of such research that reveal similarities and differences for threshold damage caused by nanosecond, picosecond, and femtosecond pulses.

Title: Interactions of intense picosecond VUV pulses with matter - potential experiments during the first phase of the TTF FEL project

Dr. Jacek Krzywinski
Polish Academy of Sciences / DESY

Abstract: The TTF FEL project is divided into two phases. The main goal of the first phase is to prove the principle of operation of SASE FEL in the 50 nm range and to gain the experience needed for the completion of the TTF FEL operating at 6 nm wavelength. All experiments using TTF FEL radiation require precision optics that can withstand tremendous power density of a photon beam. At the FEL soft X-ray energies it is difficult to predict the performance and lifetime of optical components. Therefore it is difficult to design an adequate optical layout for the experimental area. It is very important to study the problem both theoretically and experimentally in an early stage of the FEL project. In this contribution potential experiments with 200 MW, 1 psec radiation pulses during the first phase of the TTF FEL project will be discussed. A concept of an experimental chamber furnished with a focusing mirror and electron and ion spectrometers will be presented. The arrangements will make it possible to study interactions of the radiation pulses with matter up to power densities of $10^{16}$ W/cm$^2$. A possibility to study interactions between light and matter when the FEL radiation frequency changes in the vicinity of plasma frequencies of investigated samples will be also considered.

Title: Limits on focused beam intensity for molecular structure measurements using an XFEL

Prof. Seb Doniach
Department of Applied Physics, Stanford University

Abstract: Electrodynamical effects of highly focused X-rays on atomic or molecular electrons are analyzed. Calculations indicate that for a 1.5 Å SLAC LCLS beam focused down to field strengths on the order of or greater than $\sim 10^{12}$ V/m, most of the lower $-Z$ constituents of biological molecules should become fully ionized in times substantially shorter than the XFEL pulse.
Performance of high heat flux hard X-ray optics at third generation synchrotron sources

Dr. Andreas K. Freund
ESRF / Experiments Division

Abstract: An overview of X-ray crystal optics is presented. Various solutions to the head load problems arising at third generation high energy storage rings are reviewed. These comprise cryogenic cooling of optical elements based on Si, Ge and diamond, active-adaptive systems and single-crystal diamond optics.

Title: Power considerations for the TESLA FEL: Photon beam transport and monochromatization

Dr. Josef Feldhaus
HASYLAB at DESY

Abstract: The TESLA multibunch operation is expected to produce 1 Å X-rays with ~1 kW average coherent power and a divergence of the order of 1 microradian. For many experiments the natural spectral bandwidth will be too large, and in many cases one would like to deflect the light into different experiments or concentrate it into a narrow spot. It will be shown that, despite the gigantic average power density, it is not hopeless to use mirrors and monochromatic crystals, provided one resorts to low-Z materials at appropriate distances.

Title: Some ideas on testing LCLS optics without an LCLS

Dr. Malcolm R. Howells
LBNL / Advanced Light Source

Abstract: We discuss some general problems and nonproblems in designing optics for the LCLS. We pay special attention to experiments such as X-ray holography that have been successfully accomplished in the past in spite of very imperfect optics. We discuss in a general way the problem of surface damage due to the high ionizing power of the LCLS pulse and the effect of grazing incidence to understand the degree to which we can concentrate an existing X-ray beam so as to approach the instantaneous power per unit area of the LCLS. We discuss ways to concentrate soft X-rays (which appear to be the most damaging) as a way to imitate the effect of a hard-X-ray LCLS.
Title: Bent Crystal Optics for X-ray Flash Sources

Prof. Eckhart Foerster
University of Jena / X-Ray Optics Group

Abstract: A hundred years after the discovery of X-rays there is an intense development of XUV flash sources such as laser-produced plasmas, pinches, dedicated synchrotrons and Free Electron Lasers. The availability of such sources stimulates important applications and needs high performance X-ray optics. As examples real time X-ray spectroscopy and X-ray propagation through resonant attenuating media will be sketched. Then use of 1D- and 2D-bent crystals in X-ray diagnostics of flash sources will be described both theoretically and experimentally.

Title: Properties of PETRA for the characterization of optical elements for X-FEL

Dr. Horst Schulte-Schrepping
HASYLAB at DESY

Abstract: Electron beam and insertion device parameters of the new undulator beam line on PETRA are used to calculate the peak in-band powers and power densities that could be attained by focusing the output radiation using available optical techniques. The results suggest that the highest densities likely to be obtained would fail to match those in the raw SLAC LCLS beam by two or more orders of magnitude.

Title: Interaction of Ultra-Short Pulses with Matter: Prospective Applications to X-Ray Diagnostics of Plasma and Condensed Matter

Dr. Jean Francois ELOY
CESTA

Abstract: We considered the time dependence of transient photoconductivity effects induced on the surface of semi-conducting materials with ultrashort EM pulses involving an associated high electromagnetic field. By means of new relationship, our calculations involved the local displacement currents due to electronic transitions resulting from high EM fields effects. Our first results confirm a significant variation of transient reflectivity in the hundred femtosecond range as previously reported.

The responses of a dispersive and dissipative medium or bounded plasma to an initially localized ultrashort electromagnetic pulse have been investigated by using a Green’s function technique. Recently, an inverse symbolic method has been developed for describing space-time
evolution of ultrashort electromagnetic pulses in various media. Linear analysis shows that no-wake-oscillations occur for \( v^2/\omega_p^2 \geq 0.8 \), \( v \) being electrons collision frequency and \( \omega_p \) the plasma frequency. For the domain where \( v^2/\omega_p^2 \approx 0.8 \), i.e. when the medium-dependent linear term of a renormalized form of the field equation is negligible, the influence of non-linearity should become relatively important, particularly for high fields.

The use of ultrashort pulses for diagnostic of fine structure inhomogeneities may offer interesting possibilities for investigations of plasmas (fusion experiments) or other media under extreme conditions. In order to apply a well-known laser time-equivalent sampling technique, we particularly consider an original approach involving the implementation of X-ray ultrashort pulses generated by either femtosecond laser interaction with a metallic target or synchrotron radiation pulse emitted by interaction of relativistic electron beam with a periodic magnetic field.

Title: Bunching of X-Rays for Generating Ultra-short Pulse Trains

Dr. Jean-Francois ELOY
CESTA

Abstract: The optical pulse compression is currently accomplished in two steps: 1) frequency sweep is impressed on the pulse by passing through a stretcher to provide an additional bandwidth, 2) the pulse is compressed by using a dispersive delay line involving a grating pair in a parallel diffraction position. The interaction of laser beam with matter or relativistic electrons with periodic magnetic device as an "undulator" or "wiggler" are able to generate an instantaneous frequency of X-ray pulse increasing with time. Therefore, this technique of pulse compression can be used in the X frequency range by using an assembly of grating pairs to stretch and compress successively the X-ray pulse. We propose an original layout for bunching and pulse-shaping X-rays generated by these types of interactions.
Appendix C: Workshop Registrants
LCLS WORKSHOP REGISTRATION LIST
January 23rd-24th, 1997

Dr. Masami Ando
KEK
1-1 Oho
Photon Factory
Tsukuba, Ibaraki 305,
JAPAN
81-298-64-5676
81-298-64-7529
ando@kekvax.kek.jp

Ted Cremer
SSRL
PO Box 4349, MS 99
Stanford, CA 94309-0210
(415)926-4660
(415)926-3600
cremer@slac.stanford.edu

Dr. Paul Bergstrom
LLNL
P&ST - N. Division
7000 East Ave., MS L-41
Livermore, CA 94551-0808
(510)424-5775
(510)422-9560
palko@llnl.gov

Dr. Roger Carr
SSRL
PO Box 4349, MS 69
Stanford, CA 94309-0210
(415)926-3965
(415)926-4100
carr@slac.stanford.edu

Paul Csonka
University of Oregon
Dept. of Physics
Eugene, OR 97403
(541)346-5205
(541)346-5217
pcsonka@oregon.uoregon.edu

Prof. Sebastian Doniach
Stanford University
MC 4090
Applied Physics 204
Stanford, CA 94305
(415)723-4786
(415)725-2189
sxdwc@slac

Dr. Max Cornacchia
SSRL
PO Box 4349, MS 69
Stanford, CA 94309-0210
(415)926-3906
(415)926-4100
cornacchia@slac.stanford.edu

Dr. Josef Feldhaus
DESY
HASYLAB
Notkestrasse 85
D-22603 Hamburg,
GERMANY
49-40-89983901
49-40-89982787
feldhaus@desy.de

Prof. Eckhart Foerster
University of Jena
Max-Planck Soc. Rsch. Unit "X-Ray Optics"
Max-Wien-Platz 1
07743 JENA,
GERMANY
49-3641-636209
49-3641-636126
foerster@roentgen.physik.uni-jena.de

Dr. Andreas Freund
ESRF
Experimental Div.
Av. des Martyrs, B.P. 220
F-38043 Grenoble, CEDEX
FRANCE
33-47-688-2040
33-47-688-2542
freund@esrf.fr

Jerome Hastings
BNL/NSLS
Bldg. 725D
Upton, NY 11973
(516)344-3930
(516)344-3238
hastings@bnl.gov

Malcolm Howells
LBNL/LALS
MS 2-490
1 Cyclotron Rd.
Berkeley, CA 94720
(510)486-4949
(510)486-7696
howells@lbl.gov
<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Address</th>
<th>Phone Numbers</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Lynn Kissel</td>
<td>LLNL</td>
<td>P&amp;ST - V Division</td>
<td>(510)423-7940, (510)423-0246</td>
<td><a href="mailto:lkissel@llnl.gov">lkissel@llnl.gov</a></td>
</tr>
<tr>
<td>Dr. Dennis Mills</td>
<td>ANL/APS</td>
<td>Experimental Facilities, MS 401</td>
<td>(630)252-5680, (630)252-9303</td>
<td><a href="mailto:dmm@aps.anl.gov">dmm@aps.anl.gov</a></td>
</tr>
<tr>
<td>Dr. Horst Schulte-Schreppe</td>
<td>DESY/HASYLAB</td>
<td>Notkestrasse 85</td>
<td>(49)40-890982925, (49)40-890982926</td>
<td><a href="mailto:schulte@desy.de">schulte@desy.de</a></td>
</tr>
<tr>
<td>Dr. Jacek Krzywinski</td>
<td>Polish Acad. Sci./DESY</td>
<td>FDEF</td>
<td></td>
<td><a href="mailto:krzyw@gamma1.ifpan.edu.pl">krzyw@gamma1.ifpan.edu.pl</a></td>
</tr>
<tr>
<td>Dr. Richard More</td>
<td>LLNL</td>
<td>P&amp;ST - V Division</td>
<td>(510)423-7940, (510)423-0246</td>
<td><a href="mailto:germaine.brassinga@quickmail.llnl.gov">germaine.brassinga@quickmail.llnl.gov</a></td>
</tr>
<tr>
<td>Roman Tatchyn</td>
<td>SSRL</td>
<td>PO Box 4349, MS 69</td>
<td>(415)926-2731, (415)926-4100</td>
<td><a href="mailto:tatchyn@slac.stanford.edu">tatchyn@slac.stanford.edu</a></td>
</tr>
<tr>
<td>Gerhard Materlik</td>
<td>DESY/HASYLAB</td>
<td>Notkestrasse 85, D-22603 Hamburg</td>
<td>(49)40-89982484, (49)40-89982882</td>
<td><a href="mailto:materlik@vxdesy.desy.de">materlik@vxdesy.desy.de</a></td>
</tr>
<tr>
<td>Dr. Heinz-Dieter Nuhn</td>
<td>SSRL</td>
<td>MS 69, PO Box 4349</td>
<td>(415)926-2275, (415)926-4100</td>
<td><a href="mailto:nuhn@slac.stanford.edu">nuhn@slac.stanford.edu</a></td>
</tr>
<tr>
<td>Dr. Rosemary Walling</td>
<td>LLNL</td>
<td>PS&amp;T - V Division</td>
<td>(510)422-4104, (510)423-7228</td>
<td><a href="mailto:rwalling@llnl.gov">rwalling@llnl.gov</a></td>
</tr>
<tr>
<td>Ian McNulty</td>
<td>ANL</td>
<td>Exper. Fac.-Insertion Devices</td>
<td>(630)252-2882, (630)252-9303</td>
<td><a href="mailto:mcnulty@aps.anl.gov">mcnulty@aps.anl.gov</a></td>
</tr>
<tr>
<td>Dennis Palmer</td>
<td>SLAC</td>
<td>ARD-A, MS 26, PO Box 4349</td>
<td>(415)926-4611, (415)926-4999</td>
<td><a href="mailto:dtp@unixhub.slac.stanford.edu">dtp@unixhub.slac.stanford.edu</a></td>
</tr>
<tr>
<td>Dr. Shigeru Yamamoto</td>
<td>KEK</td>
<td>1-1 Oho, Photon Factory</td>
<td>(81)298-64-5680, (81)298-64-7529</td>
<td><a href="mailto:shigeru@kekvax.kek.jp">shigeru@kekvax.kek.jp</a></td>
</tr>
<tr>
<td>Apurva Mehta</td>
<td>SSRL</td>
<td>PO Box 4349, Stanford, CA 94309-0210</td>
<td>(415)926-4791, (415)926-4100</td>
<td><a href="mailto:mehta@slac.stanford.edu">mehta@slac.stanford.edu</a></td>
</tr>
<tr>
<td>Prof. Kazimierz Rzazewski</td>
<td>Polish Academy of Sciences</td>
<td>Center for Theor. Physics</td>
<td>48-22-470920, 48-22-431369</td>
<td><a href="mailto:kazik@theta1.ifpan.edu.pl">kazik@theta1.ifpan.edu.pl</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>