UCRL-89430
PREPRINT

UCRL--69430

DE83 015841

**Development of Soft X-ray Streak Cameras at
Lawrence Livermore National Laboratory**

**Hector Medeck
Glen E. Phillips
John F. Bushman**

**This paper was prepared for submittal
for the Proceedings of the
Society of Photo-Optical Instrumentation Engineers**

June 27, 1983

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

**Development of Soft X-ray Streak Cameras at
Lawrence Livermore National Laboratory***

Hector Medeck, Glen E. Phillips, John F. Bushman, Laser Fusion Program,
Lawrence Livermore National Laboratory, P. O. Box 5508, Livermore,
California 94550

Abstract

Soft x-ray streak cameras are used in conjunction with several instruments for the diagnostic of laser irradiated targets. A program was undertaken to develop cameras satisfying the requirements of the laser facility, to improve the reliability and performance of the camera and to reduce the level of effort required to set and operate each diagnostic.

The implemented soft x-ray streak cameras can be operated either manually or automatically.

Soft X-ray Streak Cameras

The development of a soft x-ray streak camera for the detection of subkilovolt x-rays with tens of picoseconds temporal resolution has been described in several publications, see, for instance Ref. 1.

Soft x-ray streak cameras are used in the Laser Fusion Program as detectors for spectrometers (diffraction gratings, crystal and mirror-filter combinations) and for microscopes (axisymmetric reflection

and pinholes). The experience collected using this device indicates the need to improve its performance and reliability and to simplify its construction and operation. Two models of soft x-ray streak cameras were implemented considering the special requirements of a high power laser irradiation facility. At the present time up to six soft x-ray streak cameras are used on a typical laser shot and this number will increase in the future. The level of effort and crew required to set, align and operate all these cameras can be substantially reduced with the proper implementation of the camera and simple procedures to use it.

The high reliability of the camera, insuring the collection of data from each shot, is an important requirement since little or no shot redundancy is included into the experiment planning. Human errors lead to damage of the camera and failure to collect the data. Solutions to these problems are the simplification of all procedures and making these procedures automatic whenever possible.

We implemented and use two models of soft x-ray streak cameras. Model 2, for general use is shown in Figure 1, and Model 3, best adapted to crystal spectrometers is shown in Figure 2. Both cameras use the RCA C73435A image converter tube, operating in the streak mode. Transparent photocathodes convert the soft x-ray flux into an electron beam. Photocathode materials, such as gold, cesium-iodide and aluminum are deposited on a substrate such as thin carbon foil or plastic film. The protection of the fragile photocathodes was a dominant consideration in the design of both cameras. Differential pressures of one Torr or less across the photocathode destroy it. The obvious approach of providing a

valve chamber at a high vacuum. Two other valves are located at the valve chamber, one for initial vacuum roughing and the other for venting the camera with dry nitrogen. The operation of the cathode positioner, front valve, auxilliary vacuum valve, vent valve and photographic film positioner is performed with electrical motors. Microswitches provide information on the status of each controlled component. The use of electrical motors simplifies installation and removal procedures and facilitates the transportation and storage of the camera under vacuum. The valve chamber of Model 2 is made of stainless steel. The entire piece is put together with a two step vacuum brazing operation.

The Model 3 camera emphasizes a short front end to satisfy crystal to photocathode distance requirements on crystal spectrometers. The reduction in length was achieved by eliminating the front valve and by reducing the width of the electrical insulation between the image converter tube and the grounded front end. A 1/8" teflon washer provides the insulation between the tube and front end. Furthermore, advantage is taken of the teflon sealing characteristics, the same teflon washer provides the vacuum seal.

The alignment of the various diagnostic setups deserve special consideration. A typical diagnostic setup is shown in Figure 4, where three different vacuum environments are depicted: target chamber, instrument and streak camera. We use optical alignment techniques, with a helium-neon laser illuminator located at the port opposite to the diagnostic setup. By using valves with glass windows at the camera front

large port between the image converter tube and the camera front end does not give a good enough vacuum inside the tube for its proper operation. An ion pump is allocated to pump the image converter tube to 10^{-5} Torr range or better. Figure 3 shows a cross section of Model 2.

The approach adopted to protect the photocathode from excessive differential pressures consist in preventing the photocathode from becoming a pressure barrier between the image converter tube and the camera front end. The photocathode seals the tube only during the laser shot, at this moment the entire camera is at a high vacuum. At the retracted position the photocathode faces a transparent window through which the integrity of the photocathode can be observed without affecting the vacuum condition of the camera.

When the photocathode is inserted, its slit side can be observed through the same window. This possibility facilitates the optical alignment of the diagnostic. The positioning mechanism allows for the extraction of the photocathode through the observation window after the camera is vented to atmospheric pressure. Absorption filters are attached to the photocathode and positioned with it. The possibility of changing photocathodes and filters without removing the camera from the instrument simplifies the procedure and avoids the need for realignment of the diagnostic setup.

Model 2 has a transparent valve built into the front end or valve chamber. With a retracted photocathode the ion pump keeps both tube and

end and between instrument and target chamber the optical alignment can be performed at any vacuum condition of the three chambers. Furthermore, an open optical path is always open along the entire diagnostic allowing for a verification and last minute adjustments, when required.

We use an electronic controller to prepare the streak camera and collect the data with minimum involvement of a human operator. The controller sets two basic conditions for the camera: stand-by and shot.

The controller brings the camera to a stand-by condition by pumping it down with an auxilliary vacuum system, first, and with the built-in ion pump, second. At stand-by the following conditions exist:

- o All valves are closed
- o The pressure at the image converter tube is low
- o The cathode is retracted
- o The high voltage to the image converter tube is "off"
- o The photographic shutter is closed

Either locally or with a remote command from the Laser Control the camera is set into a shot condition, involving:

- o Cathode is inserted
- o Front valve is open
- o High voltage for the streak tube is on
- o photographic shutter is open and photographic film is contacted to the image intensifier

The controller summarizes all those conditions on a "ready" flag, locally as a light and remotely as an electric signal.

Immediately after the shot the camera goes back to the stand-by condition by reversing the sequence of the shot conditions.

The electronic controller is portable and allows for a "stand alone" operation of the camera away from the laser facility.

Reference

1. "A Soft X-Ray Streak Camera", G. L. Stradling, D. T. Attwood, R. L. Kauffman, IEEE Journal of Quantum Electronics, Vol. QE-19, No. 4, (April 1983)

*This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

Figure 1. Model 2 Soft X-ray Streak Camera

Figure 2. Model 3 Soft X-ray Streak Camera

Figure 3. Cross section view of Model 2 camera.

Fig. 4 Typical Diagnostic Set-Up