SINGLE PASS COLLIDER MEMO

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TITLE: NOTES ON THE IMACON 500 STREAK CAMERA SYSTEM

The IMACON 500 Image Converter Camera System is a streak camera system manufactured by Hadland Photonics.¹ It utilizes an EMichron 9898 image tube with an S20UV cathode. The optics for the SLAC system are configured for IR response: good for wavelengths down to about 380 nm. The advertised resolution of the system is 2 ps.

The IMACON 500 system has been in operation at SLAC since the fall of 1983.² It has been used on the linac, primarily at CID, and at SPEAR. The camera system is very portable.

At SLAC the IMACON 500 system is used primarily to measure the time structure in the Cherenkov light generated by the accelerated particle beam passing through a thin quartz radiator. A description of the present system as used with the linac is in preparation for publication.³

A schematic layout of the IMACON 500 camera is shown in Fig. 1.

The following notes are intended to supplement the instruction manual.

1. IMACON 500 STREAK CAMERA

There is one important safety precaution.

Warning: do not shift sweep speeds without disconnecting or deactivating the camera trigger or switching to SINGLE mode.

Input trigger requirements: to trigger the streak, a pulse of +2 to +50 V amplitude into 50 Ω with a minimum risetime of 1 V/ns and minimum pulse width of 2 ns (maximum 1 ms) is required. The camera trigger must arrive at the camera only a few ns before the light pulse. See Table 1. The maximum repetition rate for the camera trigger is 1 kHz.

The intensifier is normally pulsed on by an internal trigger which comes about 0.5 μ s after the streak. If a different delay is desired, the intensifier can be externally triggered by a pulse +2 to +20 V in amplitude into 50 Ω .

In FOCUS mode the light is imaged to the center of the image tube screen. This mode is used for alignment and focusing.

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In the SYNC mode the image tube streaks, and when not streaking the image is biased to the right edge (as viewed from the rear of the camera) of the image tube screen. The SYNC mode is used during the initial timing adjustments.

In the OPERATE mode the image tube streaks, but when not streaking the image is biased completely off the image tube screen. This is the normal operating mode.

In the SINGLE mode the image tube is gated off for 1 sec starting 40 ns after streaking. The intensifier is gated on for 200 μ s within 500 ns of streaking. The repetition rate is limited to 0.5 Hz or less.

In the REP 1 mode the image tube is gated off for 1 ms starting 40 ns after the camera streaks. The intensifier is gated on for 200 μ s. The repetition rate is limited to 120 Hz or less. REP 1 is the normal operating mode.

In the REP 2 mode the image tube is not blanked off after the streak is completed. The intensifier is gated on for 200 μ s. For the SLAC camera, there is no 30 Hz limit in REP 2 mode.

2. IMACON 500 STREAK ANALYZER

The MEMORY A switch displays the stored background. To store a new background, turn the NOISE SCAN to ON while blocking the light by closing the shutter or better by blocking the Cherenkov light beam or by turning off the accelerator beam by deactivating the gun trigger. The memory switch can be in any position for a noise scan.

The MEMORY B switch displays the raw signal less whatever is stored in memory A.

The memory C display is identical to the memory B display when in the UPDATE mode. When in the STORE mode the last scan taken in the UPDATE mode is stored in memory C.

EXT trigger requirements: the trigger must be applied to the TRIG BNC on the rear panel. The trigger must be +10 V (more is probably ok up to about +50 V) and at least 50 μ s wide (100 μ s is better). The trigger for the analyzer should come 1 or 2 μ s before the light pulse reaches the camera.

In the CONT mode an internal trigger is supplied to the analyzer at an asynchronous rate.

INT is the single shot mode for the analyzer--activate by pushing the button.

The integrate period is usually set low enough to get only one signal pulse per sweep of the analyzer. The period can be adjusted between 50 ms and 900 ms.

3. INSTRUCTIONS FOR TIMING THE STREAK CAMERA

Remove the Reticon unit and watch the intensifier fluorescent screen. The camera should be in SYNC and REP 1 modes. Add delay to the camera trigger until the image appears on the right. (Left to right on the intensifier screen is the same as left to right on the image tube screen.) The camera trigger is now timed too late.

Note: reduce the ambient light until the image is dominated by the desired signal. Check by blocking the light beam or by turning off the accelerator beam, not by closing the shutter.

Remove delay from the camera trigger until the image goes away. The image goes away because the trigger is too early and thus the light signal arrives when the image tube is gated off.

The correct timing is inbetween too early and too late. A vernier delay such as a trombone should be used for the fine timing adjustment.

When the image tube sweep coincides with beam-time, the image will shift toward the center of the intensifier.

Now shift to OPERATE mode while staying in REP 1 mode. The image may go out of view but should be recovered easily by small changes in the vernier trigger delay for the camera trigger.

Reinstall the Reticon unit being careful not to jar the camera. The Reticon unit sweeps from right to left so that in SYNC mode the biased image appears on the left of the Reticon display.

Fine adjustment of the light beam onto the slits can be done with or without the Reticon unit installed.

The electronic focusing for the camera can be checked by peaking up the display using an insulated screw driver to adjust the coarse and fine focus pots found under the removable panel on the right (viewed from the rear) of the camera.

The mechanical focus controls at the front of the camera are not normally in need of adjustment.

The slit vernier is marked in units of mm. Thus one complete revolution of the vernier is 0.05 mm. The tick intervals on the stationary scale are 0.05 mm for the small ticks and 0.1 mm for the large ticks. The tick for the fully closed slit position is marked with a zero.

Reducing the slit width increases the slit resolution but decreases the light to the camera.

The resolution of the slits can be measured by noting the width of the image of the ambient light with the camera in FOCUS mode. The image under these conditions is often slightly wider if the camera is triggered (although it is possible in some situations for the image to be narrower if the camera is triggered). To be conservative, measure the slit resolution for both the triggered and the not-triggered condition and use the narrower value for a correction.

For a first order correction the slit resolution may be subtracted in quadrature from the measured width of the light pulse.

The number of Reticon channels for the slit resolution is independent of sweep speed, so the correction for a given slit width gets relatively smaller as the sweep speed is increased.

The camera shutter is operated by a 110 VAC solenoid. For local operation there is a push button on the shutter control chassis that changes the state of the shutter between closed and open. The state of the shutter can be determined by looking at the shutter status light on the camera: when the light is on, the shutter is open.

Note: keep the shutter closed when the camera is not in use or if a bright light is being used near the camera slits.

The OPERATE and REP 1 modes are used for normal operations.

Note: the total number of shots from the camera triggering circuit is limited. Trigger the camera only when setting up or when actually making a measurement.

4. CALIBRATION

The Reticon has a total of 1024 channels. Each channel is 0.025 mm wide. Thus there are 39.4 ch/mm.

The IMACON 500 manual has calibration data for the sweep speed of the image tube. The gain of the intensifier is 1.5. Table 1 shows the calibrated time represented by each Reticon channel. This information is derived from the ratio of the calibrated sweep speed and the intensifier gain divided by the number of Reticon channels per mm. The calibration for the 50 ps/mm nominal sweep speed has been verified experimentally using the S-band spacing of the accelerated electron beam pulses. The added delay incurred when shifting sweep speeds is also indicated in the table.

ACKNOWLEDGEMENTS

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REFERENCES

1 Hadlan Photonics, Ltd, Bovington, UK. The North American agent is Marco Scientific, Inc., 1055 Sunnyvale-Saratoga Rd., Sunnyvale, CA 94087, phone 6-739-9418.

2 An evaluation of a SLAC test with a "loaner" IMACON 500 system is given in a memorandum by Charlie Sinclair dated February 22, 1983.

3 J.C. Sheppard, J.E. Clendenin, M.B. James, et al., "Real Time Bunch Length Measurements in the SLC Linac," in preparation for publication in the proceedings of the 1985 Particle Accelerator Conference.

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Table 1. Calibration Data. The calibrated number of ps represented by each Reticon channel is indicated for each nominal sweep speed. The change in camera trigger delay incurred when changing sweep speed is also indicated.

Warning: do not shift sweep speeds without disconnecting or deactivating the camera trigger or switching to SINGLE mode.

Nominal Sweep Speed (ps/mm)	Calibration (ps/ch)	Delay (ns)
20	0.31	4.1
50	0.89	6.1
100	1.73	16.8
200	3.49	16.5
500	8.65	17.3
1000	18.12	12.2
2000	33.53	13.8
5000	80.94	8.8

Figure 1. Schematic diagram of the IMACON 500 camera.

Figure 2. Reticon display from April 20, 1984, of an SLC bunch of about 5×10^{10} e^- at 50 MeV. The nominal camera sweep speed was 20 ps/mm, the FWHM was 52 channels while the slit resolution was 16 channels. The resolution of the optical system for the Cherenkov light is 4 ± 2 ps.