Longitudinal diagnostics
for the emittance exchange experiment

Yin-e Sun

March 22, 2007

1 Principles of a streak camera

The durations of the UV laser pulse and the electron beam on a pico-second scale can be measured using a streak camera. While the UV light can be aligned to the streak camera directly, the electron bunches need to generate light first by hitting an OTR screen or silica aerogel. The light is then transported into the streak camera. The principle [1, 2] of a streak camera is shown in Figure 1.

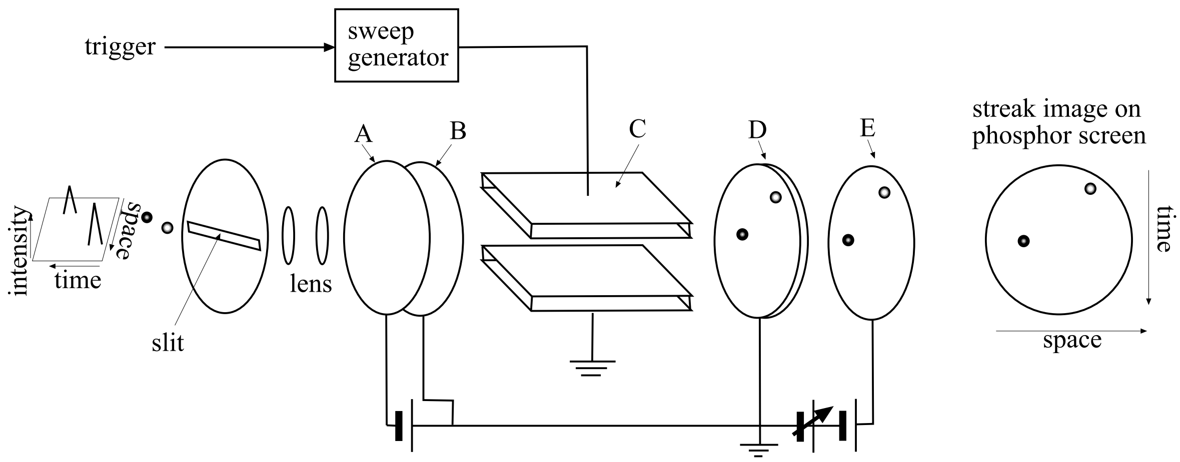

Figure 1: Operating principle of streak camera. A: photocathode; B: accelerating electrode; C: sweep electrode; D: micro-channel plate; E: phosphor screen.

The light pulses to be measured are projected onto the slit and focused by the lens to the photocathode of the streak tube. Consider two light pulses with slightly different temporal and spatial position, each with a different light intensity. Two electron pulses, with intensity proportional to the light intensity of the corresponding light pulse, are generated from the photocathode of the streak tube when the light pulses hit it. These electrons are accelerated toward the phosphor screen direction by the accelerating electrode. On their path to the phosphor screen, the electrons are deflected between a pair of sweep electrodes where a high-speed sweep voltage is applied. The deflection magnitude is proportional to the arrival time at the streak tube, with the earlier arrival pulse at the top space in the vertical direction. The deflected electrons are then conducted to a micro-channel plate (MCP), and they are amplified by thousands of times, and then converted back into light when they bombard a phosphor screen. Finally light emitted from the phosphor screen is registered by a CCD camera. So on a streak camera photo, the time axis flows from top to bottom (top being earlier in time), and the horizontal direction corresponds to the positions of the incident light in horizontal direction in space.

2 Measurement of longitudinal phase space

A system combining a streak camera with a dipole spectrometer turns out can be used to quasi-simultaneously measure the longitudinal phase space of an electron beam [3]. The spectrometer maps the beam momentum distribution into horizontal distribution in space, and and streak camera spreads the beam on a flag vertically as a function of time, and horizontally the beam horizontal distribution is maintained. Therefore, an image of the beam longitudinal phase space, momentum versus time, is obtained.

In Fig. 2, a schematic of the longitudinal phase space measurement at PITZ facility is shown [3]. Downstream the dipole spectrometer, there is a straight section (SS) and a dispersive arm (DA).

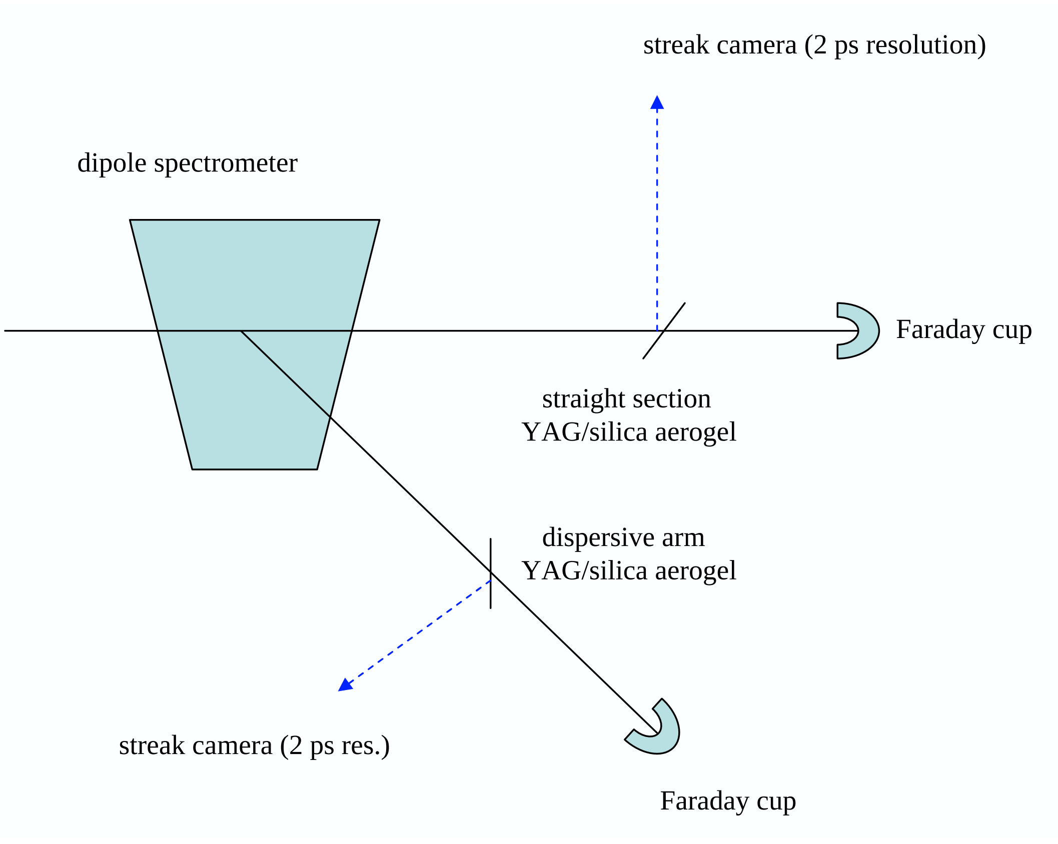

Figure 2: Schematics of PITZ longitudinal phase space measurements.

The bunch length (σ_t) can be measured in the SS. An silica aerogel Cherenkov radiator transform the bunch into light distribution, which is then imaged into the streak camera.

The momentum and its spread is measured in the DA with the help of a YAG screen and CCD camera.

Finally, the correlation between the momentum and time can be observed in the DA using silica aerogel and streak camera. The momentum axis of the image obtained by the streak camera can be scaled with the direct momentum distribution measured using YAG screen and CCD camera.

The measured numbers at PIZT are: $\sigma_t \sim 40$ ps; $\Delta p \sim 0.2$ MeV/c with p $\sim$ 5 MeV.

References

[1] HAMAMATSU Universal Streak Camera C5680 series, Instruction manual.

[2] K. Honkavaara, Ph. Piot, S. Schreiber and D. Sertore, "Bunch length measurements at TTF with a streak camera," DESY, TESLA 2000-38.

[3] J. Ronsch *et al.*, "Measurement of the longitudinal phase space at the photoinjector test facility at DESY in Zeuthen," DIPAC 2005.