Proposal for the LCLS Accelerator Science R&D program:

2D optical streaking for ultrashort electron beam diagnostics

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Description of the topic and motivation. Generation and characterization of ultrashort electron beam down to a few femtoseconds or even sub-femtoseconds are important and exciting topics in X-ray FEL field. We propose an optical streaking method here using a 10-micron wavelength laser. With a typical electron energy of a few GeV, the required laser power for streaking method is typically above a few tens GW, which is beyond the power of the present available long-wavelength laser. To overcome this issue, we first let the high energy electron pass through a gas chamber, where ionized low-energy electrons are generated. With a laser coppropagate with the high-energy electrons, the ionized low-energy electron can be streaked in vacuum. We choose a circular polarized laser to avoid the timing jitter problem between the laser and the electron beam. To extract the low-energy electrons, a DC field may be used in the system. There are quite a few advantages in this configure, since the required laser power is much lower for low-energy electron streaking, and it is jitter-free. To make it work, we propose to do modeling and simulations first to understand and design this system.

Issues to be resolved:

(1) modeling the process. This includes the generation of ionized low-energy electron, the interactions between low energy electron and laser field, high-energy electron self-fields, ion fields, and DC fields. Some collective effects have to be considered carefully;

(2) optimize the configuration. This includes the optimization on the gas type, gas pressure for low-energy electron production; the DC voltage, lase field strength, and the drift length for effective streaking; the screen material, camera setup for best resolution;

(3) study the related practical issues, such as the vacuum effects, the DC plate shape optimization, and so on.

(4) if successful, we will further explore the application to x-ray diagnostics with the 2D streaking.

Deliverables: The results of this study will be summarized in a slac report, and also in a conference paper.