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COMMISSIONING AN S-BAND HYBRID PHOTOCATHODE GUN IN MITHRA LABORATORY AT UCLA*

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Abstract

In Mithra Laboratory at UCLA, we are commissioning an S-band Hybrid gun which has a photocathode RF gun and a traveling-wave velocity buncher section contained in one integrated structure. To analyze its performance, we have measured the beam energy at various launch phases and the cavity temperatures. The beam charge was observed up to 200 pC, and emittance and bunch length measurements are now underway. We will report the detailed results of this experimental campaign, and plans for the near future.

BACKGROUND

A photoinjector is being developed for the research on the advanced accelerator technologies and its applications at Mithra (former Samurai) Laboratory, UCLA. It is designed to generate the high-brightness beam by using a 'Hybrid' gun [1]. The gun has standing-wave and traveling-wave cells. The former works for the generation of high quality beams like the RF gun and the latter acts as the velocity buncher to eliminate the magnetic chicane at low energy. This allows us to make the photoinjector compact and simple, although it adds complexity dealing with the space charge due to its high brightness at low energy.

Compactness is sometimes important, especially in the relatively small laboratory. There are groups which have adopted the hybrid gun photoinjector [2, 3].

COMMISSIONING STATUS

We have installed the gun only in the first phase of the project and measured beam properties carefully to figure out the tuning [4]. The optimization effort is still continuing, but we show some results in the following section.

The bunch length is one of the most important parameters in this system. We also tried to measure the bunch length by interferometry with coherent transition radiation (CTR). However, we could not get a good signal from the beam. Because the beam was not fully relativistic. That reduces the transition radiation. It also made it difficult to focus the beam into a small spot. This fact prevents coherent emission. It was also difficult to locate the longitudinal beam waist at the screen precisely as the bunch length changes dynamically due to the space charge effect and its low energy.

We will do the bunch measurement again after the installation of the 1.5-m linac.

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Beamline

The beamline is shown in Fig. 1. There is one spectrometer dipole magnet downstream for the energy measurement. The quadrupoles were used only for the bend line where the energy and charge measurements were performed.

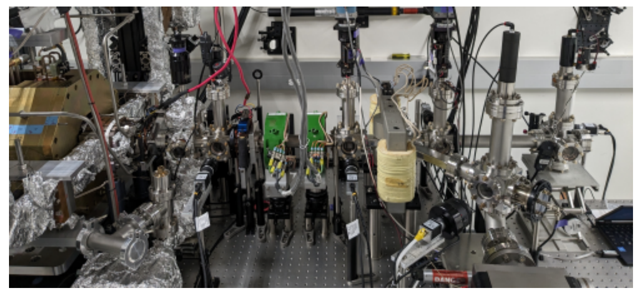

Figure 1: The hybrid gun beamline.

Cavity Temperature Tuning

The temperature tuning of the gun is key for the operation of the hybrid gun. Because it changes the RF phase advance between the standing-wave and traveling-wave section and it modifies the following beam dynamics a lot.

We measured the slope of the RF phase at the RF pickup in the first standing-wave cell after the input RF pulse had gone so that we could measure the frequency detuned by the temperature. Because the detuned frequency was displayed as a linear function of time in the phase measurement. Figures 2 and 3 shows the typical plot of RF amplitude phase with different temperature.The change of the phase slope in the tail is more clear than the difference in the maximum amplitude.. We tuned the temperature so that the last slope became flat.

Charge

The charge was measured by the Faraday cup at the end of the spectrometer beamline. The emission was linear to the laser power. The image charge did not turn off the emission in this range as shown in Fig. 4.

The QE at different launch phases in Fig. 5 shows the Schottky effect. The QE itself was not great as we used an old cathode and did not care about efficiency at this moment. It should be considered when users demand the beam with high charge for their experiments.

Emittance

We used a pepper-pot method [5] to measure the emittance. The pepper-pot mask was placed before the spectrometer and the imaging screen after the magnet. The data was corrected

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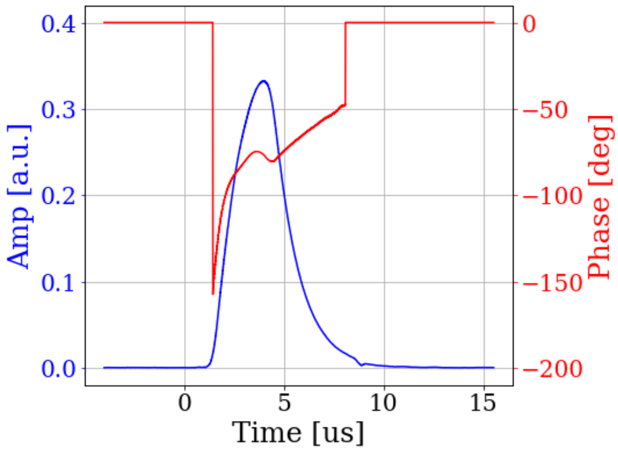

Figure 2: RF amplitude and phase at the first standing-wave cell. The cavity was detuned.

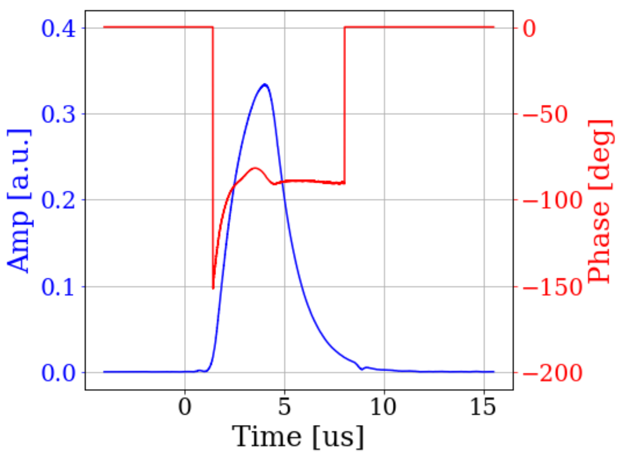

Figure 3: RF amplitude and phase at the first standing-wave cell. The cavity was tuned well.

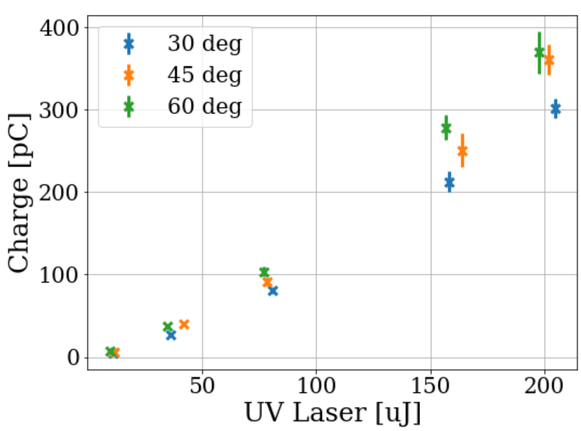

Figure 4: The beam charges as a function of the UV laser energy.

at the RF phases, 30, 45 and 60 deg. The typical image of the pepper pot was shown in Fig. 6. The analyzed data was plotted in Fig. 7. The emittance in the simulation was 1 um. The measured emittance was not great but it was fair considering the fact that the laser profile (Fig. 8) was not ideal and that the tuning was not optimized.

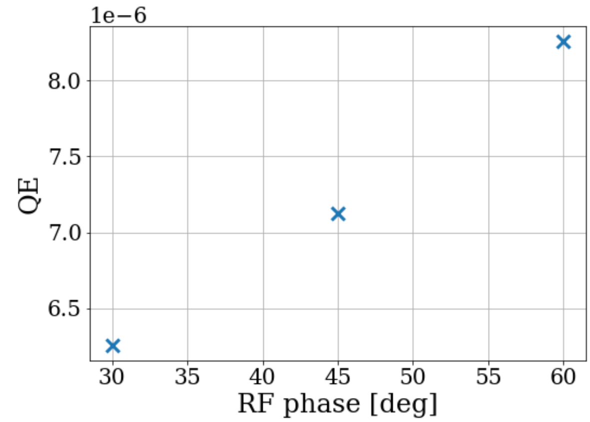

Figure 5: The quantum efficiency of the photoemission as a function of the RF phase.

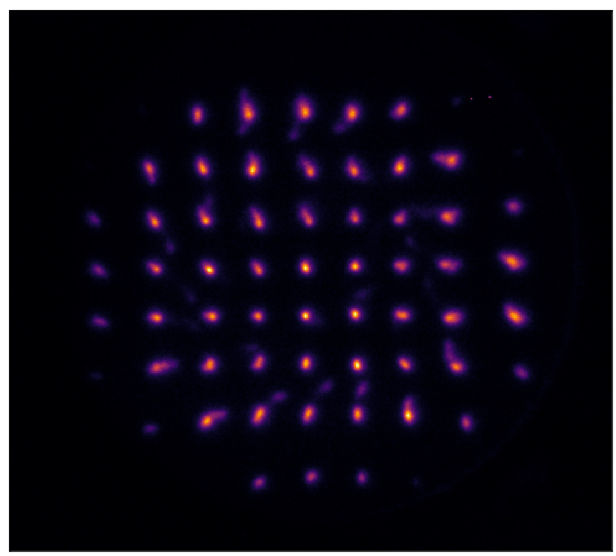

Figure 6: A typical pepper-pot image.

FUTURE PLAN

A 1.5-m linac manufactured by Research Instruments GmbH is planned to be installed this summer. By this linac we will be able to obtain 30 MeV beams. The space charge effects are dramatically reduced compared to the 3-MeV beams after the gun, although it is not negligible at the beam waist. As a result, the bunched beam can keep its short length after the linac. With the proper emittance compensation scheme, we will be able to obtain beams with small emittance. As stated before, the bunch length measurement with CTR is planned and expected to be easier with this beam than one at 3 MeV.

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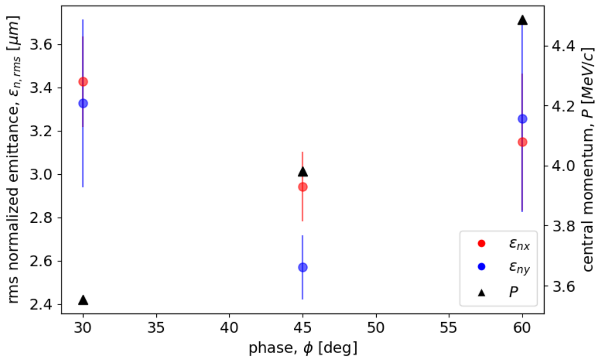

Figure 7: The normalized transverse emittances and the momentum of the beam as a function of the RF phase.

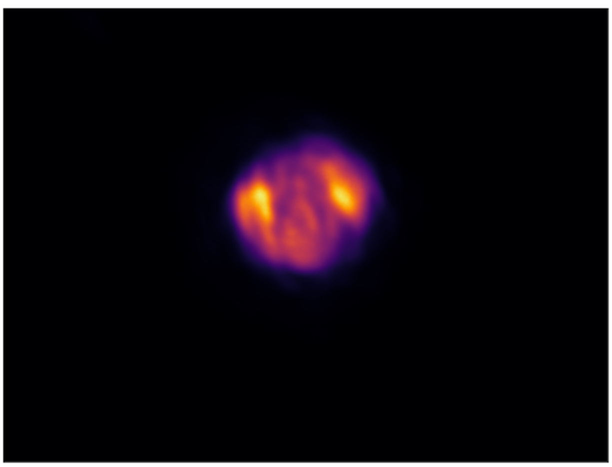

Figure 8: A typical dummy cathode image.

The 30-MeV upgrade allows us to do various experiments [4]. The experiment of an ionosphere electron simulator by using a plasma wakefield acceleration is planned after the commission of the linac. The inverse Compton scattering with the Ti:Sapphire laser for the generation of keV X-rays is being considered. The experiment for the observation of the long-term behavior of the beam plasma wakefield in the large plasma device (LAPD) [6] is being discussed as a future project.

CONCLUSION

The commissioning status of the hybrid photoinjector at Mithra Laboratory, UCLA was reported. The 3-MeV beam was generated and we measured the beam properties except for the bunch length. The measured beam quality was fair for the unoptimized beam. A 1.5-m linac will be installed this summer for the 30-MeV beam generation and it will enable us to conduct various experiments.

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