Motivation
RF photoelectron sources with superconducting cavities provide the potential to generate high quality, high brightness electron beams for future accelerator applications. Helmholtz-Zentrum Dresden-Rossendorf provides a test stand for SRF gun technology. The SRF Gun can also be used as an electron source for the two-stage superconducting linear accelerator ELBE. Future applications, such as driving X-Ray FEL facilities, require a good understanding of the longitudinal phase space distribution of the photoelectron source. Furthermore, in order to provide a stable, high quality electron beam sources of dark current as well as unwanted beam transport from the SRF gun to the linear accelerator must be investigated.

Longitudinal Phase Space

Diagonal beamline with 180° dipole
Measurement for two different laser phases 49.4° and 56.6°

- Beam Energy $E_{beam} = 3.59$ MeV
- Energy Spread $\alpha_{kin} = 1.21 \pm 0.03$ (49.4°) and $\alpha_{kin} = 1.06 \pm 0.03$ (56.6°)
- Bunch length $\sigma_t = 2.3 \pm 0.5 \, \text{ps}$ (49.4°) and $\sigma_t = 3.2 \pm 0.5 \, \text{ps}$ (56.6°)
- Correlated energy spread represents the two energy spread minima from SRF gun at low laser phase and 57°
- Vertex shift at both minima is zero
- Uncorrelated energy spread nearly constant at 8 keV dominated by thermal and RF contributions
- Bunch length shorter than laser pulse length of 6 ps due to RF-compression
- Bunch length and longitudinal emittance grow linearly with laser phase and therefore with bunch charge

Longitudinal Parameters at cavity entrance

Dark Current and Energy Acceptance of the Dogleg

- Dark current 18±2 nA (Faraday Cup)
- One significant dark current peak at 2.3 MeV
- Field emission at the cavity walls
- Unwanted beam transport to ELBE determined by energy acceptance of the dogleg

Measurement: Variation of gun gradient between 5.3 MV/m and 9.7 MV/m (i.e. energy [3.2 MeV, 3.6 MeV])

Emission time $\alpha_t \approx 10.7 \pm 2.6 \, \text{ps}$
Overestimated due to rising Schottky effect, beam dynamics, fit quality and accuracy of the displayed laser phase (± 0.5°)

J. Rudolph, “Bunch Length Measurements and Status of the Slice Diagnostics at both minima is zero”
S. Kirschweg et al., “Photo-electron beam longitudinal phase space tomography studies at the ATF”, Proceedings of LINAC'00, Monterey, California (2000)