Optical Transition Radiation for Non-relativistic Ion Beams

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In this contribution, the results of applying the Optical Transition Radiation (OTR) beam profile monitor technique to a non-relativistic ion beam are presented. Usually beam profiles are measured with Secondary Electron eMission Grids (SEM-Grid), scintillating screens or Beam Induced Fluorescence (BIF) monitors [1]. As an alternative, OTR has been investigated [2] using an 11.4 MeV/u ($\beta = 0.16$) Uranium beam at the GSI UNIversal Linear ACcelerator (UNILAC). OTR is a classical electrodynamic process where the emitted photon number depends on the square of the ion charge state. Usage of a carbon stripping foil (570 µg/cm^2) to increase the mean charge state of ions, compensated the low beam energy and allowed imaging the ion beam. Various experiments, using a non-relativistic beam, have been performed to estimate signal strength and evaluate the working regime of the OTR technique.

Results

Measurements were performed with 11.4 MeV/u Uranium beams of intensities up to $1 \cdot 10^{10}$ particles per pulse (ppp) and 300 µs pulse length for two target types: stainless steel disc and aluminized polyimide foil. The light was observed by an Image Intensified CCD camera (ICCD).
As transition radiation is instantaneously formed, we could measure the signal strength as a function of time to exclude long emission from any background sources.

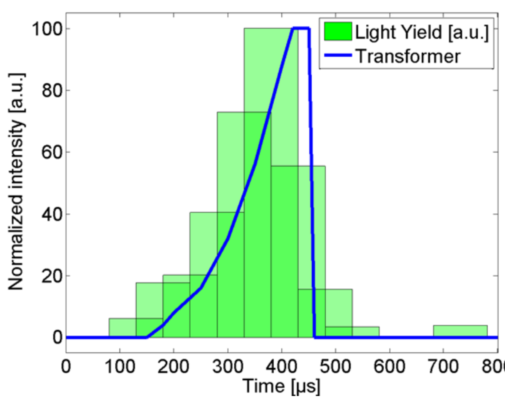

Figure 1: Time response of OTR (green) and beam current transformer signal (blue) of an $U^{\sim 73+}$ ion beam with 300 µs pulse duration. Each bar shows the OTR signal strength in a shifted 100 µs time window.

The ICCD was gated with 100 µs time window and shifted along the whole macro-pulse. The measured signal proves that only prompt emission was acquired as expected for the OTR effect (Figure 1).

In comparison to scintillating screens, OTR has the advantage of perfect linearity to the number of incident particles without risk of saturation. In our UNILAC studies the OTR signal shows linear behaviour with respect to the incident particle number.
To determine the imaging qualities of the OTR method, additional profile measurements with a SEM-Grid have been applied. In Figure 2, profiles show good agreement, but the origin of the observed shoulder in the OTR profile is not yet clear.

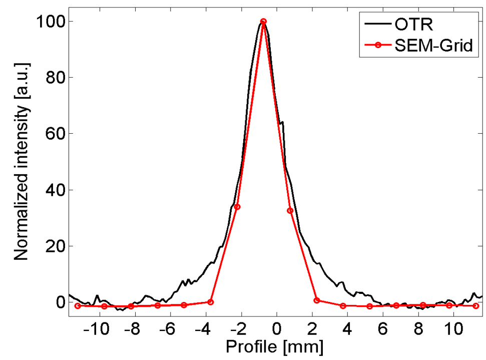

Figure 2: Comparison of the beam profile for OTR (black) and SEM-Grid (red). Beam parameters: $U^{\sim 73+}$, 11.4 MeV/u, $2.6 \cdot 10^8$ ppp in 300 µs.

Usability of the OTR method to obtain profiles of non-relativistic ion beams in the UNILAC was successfully demonstrated. Measurements indicate that observed signal levels are sufficient to allow imaging at particle intensities as low as $2 \cdot 10^7$ ppp. We observed that the signal has a linear dependency to the incident particle number. Secondly, beam profiles of SEM-Grid and OTR are in reasonable agreement. Moreover, OTR has the advantage to directly display the two dimensional beam shape. By spectroscopic studies a significant contribution of blackbody radiation could be ruled out.

Acknowledgments

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References

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